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The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled A REVIEW OF SCIENCE 10 AS A COURSE IN INTEGRATED PHYSICAL SCIENCE WITH SPECIAL REFERENCE TO ITS BACKGROUND, PURPOSES, IMPLEMENTATION AND CLASSROOM PRESENTATION submitted by Douglas Haig Jardine in partial fulfilment of the requirements for the degree of Master of Education.

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THE UNIVERSITY OF ALBERTA

A REVIEW OF SCIENCE 10 AS A COURSE IN INTEGRATED PHYSICAL SCIENCE WITH SPECIAL REFERENCE TO ITS BACKGROUND, PURPOSES, IMPLEMENTATION AND CLASSROOM PRESENTATION

A DISSERTATION SUBMITTED
TO THE COMMITTEE ON GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE DEGREE OF
MASTER OF EDUCATION

FACULTY OF EDUCATION

BY
DOUGLAS HAIG JARDINE
EDMONTON, ALBERTA

August, 1956.

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CHAPTER I

BACKGROUND AND PURPOSE OF THE STUDY

INTRODUCTION

Science was not always considered an acceptable school subject and "systems of education have been slow to recognize the value of science."[1] Nevertheless, with its increasing importance in human affairs during the eighteenth and nineteenth centuries, science inevitably found a certain place in the schools of the time. Its position became increasingly secure a hundred years ago when such eminent thinkers as Spencer and Huxley championed its claim to educational recognition and, today, few people will question its validity as a school subject.

It is now an integral part of our high school curriculum, and "there is wider interest and increased enrolment in science courses."[2]

Nor is the reason for its present prominence difficult to find. The modern industrial world was created by science and the implications of scientific knowledge influence the

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[1]G.W. Hunter, Science Teaching at Junior and Senior High School Levels, p. 15.

[2]National Society for the Study of Education, Science Education in American Schools, 46th Yearbook, p. 294.

daily lives of each one of us. The resulting challenge to our schools seems a clear one: that scientific discoveries be intelligently understood and their applications be used to worthy ends. Thus, "as educational opportunities for all and for longer periods are used more widely, more effectively, there is imperative need for increase in education by means of science and for spread of scientific knowledge."[3] As our scientific society becomes more complex, science teachers can reasonably anticipate continued emphasis upon their subject. The 46th Yearbook states this fact very clearly: "The alternative to omitting, reducing, or failing to improve and increase science education is to deny the achievements and impact made by science in modern living."[4]

But while the validity of science as a high school subject remains unchallenged, the aims and methods of science instruction have caused much concern to educators. For the past few decades, the purposes of science teaching have been, as have the aims of many other subjects, under persistent criticism from dissatisfied educators. These attacks have been answered by vigourous re-statements of the traditional positions or by re-assessments and revisions. How to keep the aims of science teaching consistent with the aims of modern education, as defined in each period, has taken the

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[3] Ibid., p. 13. [4] Ibid., p. 17.

energies of many concerned with an optimum development of the possibilities of science as a school subject. Even today the matter is not settled. The modern teacher, no longer concerned with the question, "Shall we teach science in our high schools?", still faces its sequel, "How are we going to teach it, and to what end?"

Evidence of this concern with educational aims is seen also in Alberta. In 1952 a new science course was introduced into grade ten in the provincial high schools. Science 10, as this course is called, represented the first step in a general revision of the entire high school science program. Its significance, however, does not end here. It is not just another science course, re-arranged and brought up-to-date factually. Science 10 acquires an additional importance in that it is the culmination of many trends which have influenced our educational thinking. In the aims of this course, science teachers will note a decided change of emphasis; they cannot be neglectful of its implications.

PURPOSES OF THIS STUDY

Many teachers will welcome the newer approach; others will be antagonistic to it; more may be uncertain of just what is involved. But, in any case, a study of the new course, its background and practicability is an important task for all science instructors. Whether they will agree or not with its

aims is, at present, beside the point; disagreement or conformity must be intelligently directed. Thus, a need to examine carefully the important phases of Science 10 is imperative. This thesis has been written in an attempt to meet this need.

This study in its attempt to evaluate the Science 10 program must consider fully the aims behind the course, but any appraisal would be inadequate if it concerned itself with these alone. For a more balanced view, two other factors must be considered as well. These are the classroom teacher and the facilities with which he has to work. As "the major factor in gaining improvement in science education"[5] the teacher has a great responsibility. No matter how well-founded the aims of any course may be, their implementation could come to nothing if the teacher is ignorant of or unsympathetic to these aims, if he is poorly qualified as an instructor, or if his facilities are unduly restricted. If this be true in an established course, how much more vital is the teacher's role in a new course which purports to alter many of the traditional objectives of the subject?

In the light of the above, the purposes of this study are as follows:

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[5] Ibid., p. 295.

1. To review, by reference to authoritative studies in the field, educational opinion on the nature and aims of the modern high-school science program. This task is attempted by:
   a. surveying historically the relevant trends and noting their influence upon present-day concepts of science teaching.
   b. determining the principles basic to the physical science and the integrated physical science programs.
   c. reviewing opinion on many factors (use of text, training of teachers, etc.) inherent in the presentation of a modern course in science.
2. To gain specific insight into the nature of Science 10 by:
   a. discerning the influence of the above trends and principles upon the construction of this course.
   b. reviewing the actual steps in its implementation.
   c. analysing the Curriculum Guide for an official declaration of aims and purposes.
3. To determine by means of a questionnaire:
   a. teacher reaction to the aims of Science 10.
   b. teacher opinion on the value of the present Science 10 course as an effective high-school subject.

c. the conditions under which it is being taught. (teachers' qualifications, equipment, etc.)

4. To assess from the above what may be the strong and weak points of Science 10.
5. To suggest means of improvement wherever shortcomings appear to exist either in the construction of the course or in its presentation.

LIMITATIONS OF THE STUDY

The writer is aware that several factors may restrict the effectiveness of the study in its appraisal of the actual teaching of Science 10. A questionnaire, at best, enjoys only a limited circulation; its construction may be defective in certain respects; furthermore, some teachers complete it thoughtlessly.

Again, much of the data may be difficult to appraise accurately. It is difficult to evaluate the effectiveness of any teacher's presentation of the course by merely indicating his years of training and some of the conditions under which he works.

It is hoped, however, that the diversity of replies has revealed a representative picture, that the careful construction of the questionnaire has given much pertinent data, and that the teachers on the whole have answered with care.

The writer is confident that the information collec-

ted can serve as a source of valid generalizations when considered in the aggregate. These generalizations, in turn, will serve to direct attention to any strengths and weaknesses in the construction and teaching of the course.

CHAPTER II

REVIEW OF THE LITERATURE: AIMS OF TEACHING SCIENCE

INTRODUCTION

That our conception of the purposes of science instruction has changed greatly is evident after even a casual reading of the literature on the subject. "The purpose of teaching physics is to teach physics -- what more?"[1] -- that succinct question and answer of the 1920's can no longer satisfy the thoughtful present-day science teacher if he has done some reading in his field. He cannot avoid being aware of newer orientations and trends -- trends which seem to be drastically altering the once conventional aims of his chosen subject.

The word 'trends' suggests some sort of continuity. In educational thought, as in most other fields, newer ideas have arisen progressively to challenge and modify the older ones. Indeed, some dissatisfaction with current aims of science education seems to have been evident for almost as long as people have looked critically at the conditions of public instruction. The importance of science in human

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[1]National Society for the Study of Education, A Program for Teaching Science, 31st Yearbook, p. 246.

affairs helped secure science a place in the high school curriculum; the increasingly cogent effect of science upon the modern world has created steady demands that scientific understandings be made a more vital factor in our every day lives. In many important studies unfavourable appraisals of current programs have formed a consistent theme. A common criticism of traditional aims is set down concisely by the 31st Yearbook as "none of these is being effectively attained, and, as commonly conceived, none is worthy of the potentialities of the subject."[2]

Criticism, however, has not been entirely destructive; with great vigour newer aims and concomitant methods have been proposed to replace the old. The question, "What is wrong with the older aims and what better aims can we use in their place?" would seem to be the concern of the authoritative investigators. To any student in the field of science teaching, the answers to this question provide an enriching background.

Although this thesis is primarily concerned with the effectiveness of the Science 10 course, that effectiveness must be measured against the aims of the course, and these aims, in turn, cannot be properly understood without some knowledge of the trends which have influenced them. It is

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[2] Ibid., p. 26.

the purpose of this chapter, then, to survey the literature on the aims of science instruction, to note the emergence of important newer ideas, to discover the nature of the more established ones they attempted to modify, and, finally, to set out a few of the more prominent attempts to orientate the curriculum towards 'modern' aims in science education.

TRADITIONAL AIMS

In the latter half of the nineteenth century, the university exerted an increasingly stringent control over not only the content of the high school courses but over their methods of presentation as well. "What fits for college, fits for life,"[3] seemed to be the slogan. Nevertheless, this influence was viewed uneasily by many who succeeded in adding a number of 'practical' courses whose aims were directed toward preparation for life rather than toward a direct preparation for college.[4] Although many of these newer subjects, history, modern languages, etc., are common today, their inclusion into the curriculum of the 70's and 80's was not entirely welcome. They were "the modern and practical subjects at which the college looked askance and mental disciplinists openly cast scorn and ridicule."[5] Yet, despite

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[3]North Central Association, High School Curriculum Re-organization, p. 7.

[4]Ibid. [5]Ibid.

this disdain, these courses did receive a measure of support:

> The idea of a high school that should frankly and without unnecessary indirection steer toward the more immediate demands of citizenship, occupation and local leadership was too well-suited to the ambitions of our practical minded citizens and too much in accord with out ever developing notions of democracy to be subdued.[6]

In an attempt to set the educational house in order, the National Educational Association set up a committee in 1892 one of whose tasks, in reviewing the high school scene, was to set forth the proper aims of instructions in the secondary schools. The committee, composed largely of college teachers and established educational leaders, published its findings in 1893 as the Report of the Committee of Ten. This report is valuable as a declaration of authoritative opinion at the turn of the century.

Its conclusions are interesting. Preparation for the duties of life was considered to be the major purpose of the high school but only for "that small proportion of all children ... who show themselves able to profit from an education prolonged to the eighteenth year."[7] The case for an exclusive high school is clearly implied. The reference to 'preparation for life', therefore, despite its modern ring, has a far from modern connotation. Capable pupils were to be prepared for life through the intellectual training they

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[6] Ibid.

[7] Ibid., p. 8.

received in mastering academic subjects. The method was the thing and the value derived from any subject was measured against the criterion of the intellectual discipline it afforded. Instruction should be "intellectually thorough, consecutive and disciplinary".[8] As the well-established subjects, such as Latin, Greek and mathematics best provided this discipline, they were to be preferred to the newer practical or life-centred ones whose study "lacked the more venerable, the surer training derived from long-continued Greek, Latin and mathematics."[9] Yet the latter were not entirely valueless; within a conservative range they could, provided they were properly taught, even be accepted for college entrance. "What fits for life will also fit for college if it is academic and rightly taught."[10] It would appear that intellectually rigourous methods were presumed to have a double value: they made certain subjects worthy of college acceptance, and they provided intellectual training which in its own right was preparation for life.

In 1932 the 31st Yearbook of the National Society for the Study of Education neatly summed up the older aims as they applied particularly to training in physics and chemistry. "The traditional support for physics and chemis-

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[8] Ibid. [9] Ibid.

[10] Ibid.

try has been stated in terms of (1) formal discipline, (2) knowledge, (3) college preparation."[11]

It would appear that the high school of the time sought to provide training for the mind -- a training most effectively acquired by a thorough academic study of certain traditional subjects. Having received this training, the student was not only intellectually disciplined but prepared for college as well.

These three aims were deemed complementary, each implied to a degree in the others. The first formal discipline, is of decided interest because it reflects a psychological conception formerly used to support the rigourously academic presentation of a subject. "The common interpretation of the disciplinary, or training, objective is one which has developed from faculty psychology"[12] which held that the mind is composed of certain discrete faculties each of which could be trained through a definite type of mental activity. Thus, for example, the faculty of memory could be developed by memorizing detailed data, and the power of observation by meticulous laboratory work. Intellectually-thorough subject matter became revered as an indispensable tool in education because mastering it provided the required exercise for the

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[11] N.S.S.E., 31st Yearbook, p. 24.

[12] Ibid., p. 26.

mental faculties; "its very difficulty was valuable as a discipline."[13]

For this purpose, the logical organization of specialized science with its quantity of involved data was held to be ideally suited:

> ...It was held that the study of the sciences possessed particular merits ...; they provided unique opportunity for mental discipline by training the faculty of observation, promoting the concentration of thought and energy and providing sense training through the manipulation of materials.[14]

Indeed, if the theory of mental discipline be valid, the exacting methods of college science were most appropriate in the high school science program. The statement, "If the subject matter is given in a thorough way, then the child is bound to get out of it as much as he puts in ..."[15] would appear, in the light of the above, to be a reasonable conclusion. It readily follows, then, that "objectives that express the disciplinary claims have invariably had largest recognition"[16] in many older surveys of teacher opinion.

In surveying the period from 1880 to 1910 which it

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[13]Progressive Education Association, Science in General Education, p. 9.

[14]Ibid., p. 8.

[15]G.W. Hunter, Science Teaching at Junior and Senior High School Levels, p. 60.

[16]N.S.S.E., 31st Yearbook, p. 24.

regards as "the heyday of formal discipline,"[17] the Progressive Education Association noted some of the effects of faculty psychology on the science program. Subject matter was highly formalized, involving a great deal of detailed classification and systemization. It was technical and difficult. There was no distinction made between instruction for college-bound students and instruction for others because the discipline suitable for college entrance was in itself valuable to all as mental training. Detailed laboratory work was stressed for the training it gave in careful observation, neatness and precision. As all students were assumed to have the same mental faculties, little regard was held for individual differences of particular needs.[18]

CRITICISMS OF TRADITIONAL AIMS

Criticism of the Disciplinary Aim. To the extent that they depended upon the theory of mental discipline for justification, the traditional methods suffered as the validity of this psychological foundation was questioned. The academic emphasis was belittled because it found "justification on a theory of mental gymnastics"[19] and because of "the

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[17]Progressive Education Association, op. cit., p. 8.

[18]Ibid.

[19]North Central Association, op. cit., p. 9.

fallacy of mental discipline."[20] In evaluating methods of science instruction as late as 1938, a writer states:

> Though modern psychology has given experimental proof that the conception of mental discipline is inadequate, much of current science teaching is not only congenial to this outmoded theory, but can only be justified in terms of it. The all too prevalent practice of requiring the memorization of fixed quotas of factual materials, the assigning of problems selected primarily for their difficulty ... are evidence of the persistence of the faculty theory of mind and its correlative education aim, mental discipline.[21]

Criticism of the Preparatory Aim. Concomitantly with the notions of formal discipline, the traditional aims and methods had been strengthened through their college orientations. First of all, the subject matter of high-school science was more or less prescribed for no student could be admitted to advanced training without a foundation in college-approved preliminary subject matter. Secondly, examination and laboratory requirements established by the university combined to force the rigourous university methods upon the high-school teaching procedures -- methods often justified in terms of the formal discipline theories now out of favour. Speaking of college domination of chemistry teaching, Hunter states:

> In 1872 standards began to be set by the colleges for acceptance of chemistry as a college entrance

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[20] Ibid.

[21] Progressive Education Association, op. cit., p. 9.

> requirement ... the result was to emphasize the techniques of laboratory procedures, to make the memorization of factual material the chief aim of the student and to deaden initiative by requiring a certain number of exercises, all of which had to be submitted as evidence of having satisfactorily completed the requirements for college.[22]

Rusk, considering the same influences on physics teaching from 1872 to 1905, notes:

> During the first twenty years, the influence was a markedly beneficial one, but during the remainder of the period, the aim of formal discipline, the introduction of too much mathematics, and the neglect of the directly useful things led to the re-organization ....[23]

Many critics complained that all students were receiving the training designed for the specialist and that the other important values of science instruction were being neglected. "... Much of the activity in science education had been in support of subjects and the question of educational values for children in the elementary and secondary schools has not been given the prominence it deserves,"[24] declares the 31st Yearbook in the introduction to its comprehensive study. Morris F. Stubbs in 1927 noted that a frequent objection against the chemistry teaching of the time was that "it aims to turn out chemists rather than intellig-

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[22]Hunter, op. cit., pp. 42-43.

[23]Ibid., p. 44.

[24]N.S.S.E., 31st Yearbook, p. ix.

ent citizens."[25] And the 46th Yearbook of the National Society for the Study of Education discussing this situation as late as 1947 declares:

> We have prepared our students for a variety of professions in which scientific knowledge and scientific methods are put to work ... we have failed, however, to educate through our science, the boys and girls who are not going to be scientists. We have not prepared a generation of adults to find their bearings in an age of science.[26]

The validity of this preparatory aim was under attack for another, but unrelated, reason. The greatly increased enrolment in the high school provided one of these. This increase greatly lessened the proportion of pupils planning to enter college. The 31st Yearbook uses this fact to further depreciate the preparatory aim. "A large proportion of pupils who study high school science do not enter college, and, of those who do, a relatively small proportion will specialize in a field of science."[27] and adds a further general condemnation, "Available data suggest at once that much of the support for this objective is of doubtful validity."[28] To add support to this statement, the 31st Yearbook

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[25]M.F. Stubbs, "The Place and Problems of Chemistry in the High School Curriculum," School Science and Mathematics, (October, 1927), XXVII, p. 742.

[26]National Society for the Study of Education, Science Education in American Schools, 46th Yearbook, pp. 248-249.

[27]N.S.S.E., 31st Yearbook, p. 25.

[28]Ibid.

quotes "available data" from the studies of Noll, Carnog and Colbert -- all of which failed to detect any advantage for the pupil on the basis of college achievement for having taken specialized science in the high school.[29] Thus emphasis upon the preparatory objective "has, in current practice, resulted in a large amount of wasted effort."[30]

Criticism of the Informative Aim. These objections to the purely preparatory aims were also, in part, attacks upon the informative one as well. But to this third aim of traditional instruction another criticism was directed. The desire to impart to the students a broad knowledge of the field far too often resulted in a pre-occupation with facts for their own sake. The subject matter had become too complex, too detailed for effective mastery, and "the texts in use have become encyclopedias of information."[31] "We shall attempt in vain to teach all the factual material that has been outlined under the special divisions commonly recognized,"[32] continues the 31st Yearbook. Often the student was so entangled in a maze of facts that he failed to get an overview of the essential concepts. In discussing high school chemistry, the North Central Association study of 1933 des-

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[29] Ibid., pp. 25-26. [30] Ibid., p. 26.

[31] Ibid., p. 24. [32] Ibid., p. 26.

cribed this subject as "a confused mass of abstract technical facts and principles, bearing few discernible relationships to actual life, but only those internal relationships which are of interest to trained scientists."[33] To this, after considering high school science in general, Hunter adds his condemnation; "The chief difficulty with science as it is taught today seems to be that factual information is amassed for its own sake and not for what it will do."[34] The 31st Yearbook comments, "Current practices in science teaching and in other fields have been severely and justly criticized for overemphasis on memory work for the purpose of enabling the pupil to reproduce unrelated facts."[35]

Furthermore, much of this subject matter so laboriously acquired was soon forgotten. Hurd in 1928 dealt with this matter and put forth a reason which suggests a basis for reform:

> ..."Why is it true that three months, or six months or a year, or two years, after having studied science ... the average student knows very little about the material covered in the course?" ... Some teachers might say, it is because the material was not learned to the point of mastery. Others might say that it is because the material is not closely enough associated with the daily life experiences or the needs of the pupils; the subject matter does not tie up with life; it doesn't function; therefore, it is soon forgotten.[36]

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[33]North Central Association, op. cit., p. 239.

[34]Hunter, op. cit., p. 225.

[35]N.S.S.E., 31st Yearbook, p. 59.

[36]A.W. Hurd, "Present Inadequacies and Suggested Remedies in the Teaching of High School Science," School, Science and Mathematics, XXVII (June, 1928), p. 638.

A NEW ORIENTATION IN THE AIMS OF SCIENCE INSTRUCTION

Hurd's comments suggest a reason for the defect as well as a criticism of it. Indeed, criticism cannot be long separated from proposals for reform. Although many critics have consistently attacked the conventional aims of high school science education, they have been no less active in emphasizing the need for newer ones which, in their opinions, must be better adapted to the requirements of twentieth century society. The essential point of most of the persistent attacks on the older aims is the charge that they had little functional bearing on actual life. They had become out of date, it was claimed, and their persistence reveals "evident discrepancies between the best thought in education and current practices in the teaching of science."[37]

Accordingly, the Committee of Ten Report of 1893 did not remain unchallenged for long. There were "dissatisfaction and remonstrance from the various groups"[38] in touch with high school pupils. Awareness of "the fallacy of mental discipline and the actualities of life"[39] caused criticism to grow in volume.

An early significant pronouncement on this matter was

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[37]N.S.S.E., 31st Yearbook, p. ix.

[38]North Central Association, op. cit., p. 9.

[39]Ibid.

issued in 1918 as The Cardinal Principles of Secondary Education by the National Education Association. In direct opposition to the Committee of Ten Report, this study put forth direct life preparation as the keystone of all effective teaching. Here the main aims of education were itemized under several functional categories: (a) health, (b) command of fundamental processes, (c) worthy home membership, (d) vocation, (e) citizenship, (f) worthy use of leisure time, (g) ethical character. To prepare the pupil for immediate and mundane aspects of living is the concern of the school. Attention is abruptly turned from values implied in the mastery per se of a subject to values contingent upon using knowledge for solving life's problems.[40]

The 1918 report was followed two years later by another entitled Re-organization of Science in Secondary Schools in which the same association attempted to set out science's peculiar values in this preparation for life. Science could, it was here stated, make particular contribution to six of these 'life' aims. These pertained to health, worthy home membership, vocation, citizenship, use of leisure, and ethical character.[41]

These two reports represent a long step in removing

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[40] N.S.S.E., 31st Yearbook, p. 18.

[41] Ibid., p. 19.

high school science from the influence of mental discipline and college preparation. Their program was a significant attempt to make the subject "more functional and effective in the every day life of students."[42] According to the 31st Yearbook:

> The recognized achievement of the Commission has been to shift emphasis in thinking concerning educational problems from values assumed to be associated with mastery of subjects to values which are more directly associated with human relations.[43]

Indeed the need for functional objectives in science instruction appears to be a main principle in recent educational literature. In this connection, a 1933 study states that "attention is now being directed mainly to the construction of curricular units of a more directly functional nature."[44] Hunter in 1934 asks this question, "The child of today is brought up in an atmosphere of practical science, and yet how many of us are explaining to him the problems with which he comes in contact in his daily life?" and continues by contending that "courses in science should first of all interpret the environment of the pupils so that they may best prepare themselves for a sane and healthy life in that

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[42]Progressive Education Association, op. cit., p. 11.

[43]N.S.S.E., 31st Yearbook, p. 19.

[44]North Central Association, op. cit., p. 4.

environment ...."[45] In discussing a new physics course in 1933, the North Central Association Committee stated their belief that "the subject material should bear upon his [the pupil's] necessities and his experiences in daily life .. .."[46]

A co-operative project carried on in seventeen secondary schools under the supervision of the Bureau of Educational Research of Teachers College, Columbia University held the view that "curricular materials and methods of teaching consciously selected because of immediate significance to human living will better serve young people than those in which such a significance, if present at all, is incidental."[47] Their aims in science teaching were clearly set "to lead young people to a clearer understanding of society, of the social function of science and of their individual needs and interests."[48] Both the 31st and 46th Yearbooks of the N.S.S.E. have approved the newer objectives. In the 31st Yearbook we read: "This committee, then, recognizes the aim of science teaching to be contributory to the

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[45]Hunter, op. cit., p. 13.

[46]North Central Association, op. cit., p. 274.

[47]Bureau of Educational Research in Science, New Directions in Science Teaching, p. 2.

[48]Ibid., p. 4.

aim of education; viz., life enrichment."[49] The 46th Yearbook, in considering the social values of science teaching states the following:

> It is becoming increasingly more important that the science teacher seek out the social implications of his materials of instruction and deal with them in such a way that they give promise of having more carry-over values to aid the pupil as he attempts to adjust to the problems encountered in his daily living.[50]

INCREASING ACCEPTANCE OF NEWER IDEAS

For their adequate fulfillment the newer ideas required two things: first, an acceptance of their validity by educators, and second, a complete overhaul of the subject matter and curriculum to guide and facilitate their implementation.

That the newer concepts were gaining acceptance is noted in many places. Speaking of general science in the decade preceding 1930, Hunter notes a "noticeable, gradual emphasis on material of civic or social value, indicating that the philosophy of education for citizenship was the keynote of the decade."[51] Although physics and chemistry up to 1933 have in his view "gone placidly along reflecting the college domination in content and method,"[52] Hunter

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[49] N.S.S.E., 31st Yearbook, p. 57.

[50] N.S.S.E., 46th Yearbook, p. 141.

[51] Hunter, op. cit., p. 39.

[52] Ibid., p. 150.

concedes that "even the more static courses in chemistry and physics are beginning to show signs of meeting life conditions of pupils more than college entrance requirements."[53]

In comparing the results of two similar questionnaires sent out to a great number of high school teachers in 1930 and in 1941, Hunter and Spore found the overall picture quite favourable to the newer objectives. These questionnaires presented a long and varied list of objectives from which teachers were requested to indicate their preferences. "In 1930 at the senior high school level the propaedeutic function stood first on the list of science objectives given by science teachers .... In 1941 it stood as twenty-third on a list."[54] This difference in preference for one of the well-intrenched 'traditional' objectives, Hunter and Spore consider most striking. They continue:

> Evidently many of the state supported schools are saying to the college and universities, 'you must take our products as we prepare them for life for we are not interested in training for college examinations as such.[55]

And the 46th Yearbook in summarizing the trends to 1945 states in referring to biology, that "during the past

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[53] Ibid., p. 112.

[54] G.W. Hunter and L. Spore, "Objectives of Science in the Secondary Schools of the U.S.A.", School Science and Mathematics XLIII (Oct., 1943), p. 640.

[55] Ibid.

ten years, particularly, the trend has been toward focusing attention less on the organization of subject matter and more on the results in the lives of the learners."[56] For science instruction in general, "The fact that so much attention is being directed toward education for effective adjustment carries a significant implication for secondary school science."[57] It would appear that the traditional emphasis upon college preparation and upon 'facts for their own sake' was lessening while a concept of science instruction with a bearing upon the concerns of everyday life was gaining increasing favour.

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[56] N.S.S.E., 46th Yearbook, p. 184.

[57] Ibid., p. 141.

CHAPTER III

REVIEW OF THE LITERATURE: MAKING THE SCIENCE CURRICULUM FUNCTIONAL

NATURE OF THE TASK

Although teachers of secondary science have become increasingly sympathetic "to the need for transferring a subject from a scholastic discipline or a formal college prerequisite into a means of direct education for the activities of life"[1], they have often lacked guidance in revising the subject matter to this end.[2]

Indeed, making the curriculum effectively life-centred is no easy task. In contrast, the construction of traditional courses was relatively clear-cut and direct. Under the standards set up by the university the purpose of instruction was clear and the methods of schieving it relatively precise. With the aid of a logically-organized text the subject matter was covered methodically and rigourously, the prescribed number of experiments were performed, and the student was examined to see if he had mastered the knowledge and techniques set out.

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[1]North Central Association, High School Curriculum Reorganization, p. 12.

[2]Ibid., p. 11.

> As long as education could be conceived as consisting mainly in the training of the faculties, the purpose of science instruction was clear. Science information was organized in systematic and logical fashion, and laboratory work was carried out with meticulous detail in order to train the faculties of observation, memory, reasoning and the like.[3]

Finally, formal examinations and laboratory tests could indicate quite clearly how effective the teaching of the materials of the course had been.

Lacking these more or less definite criteria of traditional science, the creators of functional courses, on the other hand, had to find answers to many basic questions before an adequate course could appear. The outcomes sought, the organization of subject matter, the program of evaluation, provision for specialist-minded students, and the like required attention. It is one thing "to assent to the need" for a change in emphasis in science teaching, "but another thing to effect this."[4]

Nevertheless, many attempts have been made to lay at least the broad foundation for a curriculum of functional science. A general review of some of the more important of these follows. The reader will note that although the approach may vary, the need for making science bear directly on everyday living is the basic justification for each program.

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[3]Progressive Education Association, Science in General Education, pp. 15-16.

[4]North Central Association, op. cit., p. 12.

REPORTS OF THE NATIONAL EDUCATION ASSOCIATION

The 1918 and 1920 reports of the Committee on the Re-organization of Secondary Education, in attempting a wholesale revision of the aims of education, proposed many changes in the science program. Some of the more noteworthy were: that science instruction be continuous and progressive throughout the entire school, that greater attention should be given to individual abilities, and that a revision of the old-fashioned disciplinary functions of science should be undertaken.[5] Perhaps its greatest contribution was an attempt to make science instruction bear more directly on the pupil's life by outlining those areas of everyday living where science instruction could be particularly fruitful. These were: health, worthy home membership, vocation, citizenship, worthy use of leisure, and ethical character. To constitute these six areas as basic objectives of science instruction was a determined break from traditional thinking with its stress on disciplinary and preparatory values.[6]

The next step in such a program was clear. The educator had to determine those specific facts, experiences, and skills needed by high school pupils to live most effectively,

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[5]National Society for the Study of Education, A Program for Teaching Science, 31st Yearbook, pp. 18-19.

[6]Ibid.

and then construct a curriculum that would best provide them. Unless an item of subject matter made effective contribution to one or more of the six fields chosen as objectives it would be excluded. All parts of the curriculum must "be submitted to the test of social and personal relevancy in a modern democratic society."[7]

31st and 46th YEARBOOKS OF THE N.S.S.E.

The National Association for the Study of Education is an important body whose pronouncements are considered highly authoritative. The 31st and 46th Yearbooks of this group, after evaluating previous and current trends in this field, attempt to set forth a comprehensive science program.

The 31st Yearbook, published in 1932, considers that the basic aim of all education is to enable the individual "to participate intelligently and with satisfaction in the experiences of living."[8] To this end of enriched living, science instruction shares with all other types of instruction the task of contributing as effectively as possible.

Indeed, science has a special contribution to make because we live in a world so greatly altered by scientific discoveries that a knowledge of their implications is needed

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[7]North Central Association, op. cit., p. 11.

[8]N.S.S.E., 31st Yearbook, p. 43.

for an understanding of society itself. Furthermore, scientific attitudes which should arise with the study of science are themselves valuable in dealing with many of the problems of everyday life. In short, both an understanding of the environment and the ability to use the scientific method in dealing with it can contribute to the goal of 'life enrichment' by helping the student live more intelligently.[9] They are, therefore, valid objectives of science instruction.

This understanding of the environment can best be achieved, in the Yearbook's view, by presenting to the pupil the most useful principles of science and by presenting them so effectively that their nature and implications are thoroughly grasped.[10] For this purpose, all instruction, even that of the highly specialized sciences, must be organized around these generalizations.

From all the generalizations of science, which ones must the educator choose for his purpose? A basis for selecting the best ones must be established. The Yearbook's criterion is this: Educators must carefully choose "the principles and generalizations that ramify most widely into human affairs."[11] The reader will note the emphasis upon social values, the need for 'functional' science.

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[9] Ibid., p. 43.

[10] Ibid., p. 44.

[11] Ibid., p. 43.

> The school will contribute to life enrichment if its activities are of the kinds from which ideas may be developed and if the ideas may in turn be associated into principles and generalizations that are interwoven into human experience.[12]

When the most useful principles have been selected by this standard, they must be broken up into component ones, and these in turn into still simpler ideas. In this way, something suitable, even for the most elementary grades, can be found. This is a vital task. The school must start in the lowest grades and year by year build up ever-enlarging understandings so that "each grade level shall present an increasingly mature development of the objectives."[13] In this process of building up a generalization from simple facts we follow the scientist as he has progressed along the same path. Thus the pupil "is taken through the experiences of a discoverer, and these experiences are clarified so that he may come, in as large a measure as possible, to an appreciation of the methods of thought and action used by a scientific worker."[14]

Indeed, this progressive enrichment of an idea lends itself admirably to the growth of scientific attitudes which the Yearbook defines as "those of respect for tested truth and the methods by which it is revealed"[15] and considers

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[12] Ibid., p. 42. [13] Ibid., p. 44.

[14] Ibid., p. 47 [15] Ibid., p. 27.

collectively a concomitant aim of science education. The related skills which together constitute 'the scientific method' can also become a valuable part of the student's thinking if care is taken to nourish them.[16] Since they are useful tools in life adjustment, their acquisition is likewise a valid outcome of science instruction.

This twofold purpose of science education is emphasized in the following statement:

> ... The attainment of an objective means the attainment of understanding, together with the development of mental attitudes that may be associated with understanding, and it means the development of ability to use techniques and methods of working and thinking.[17]

The 46th Yearbook, entitled Science Education in American Schools and coming fifteen years later than the 31st, reaffirms, in the main, the outlook of its predecessor. It agrees with the concern for social and personal goals because all the objectives of science teaching "are means to the end of more effective adjustment."[18] It views favourably the two-fold general statement of the 31st, that science materials must be organized for understanding around worthwhile generalizations and that the acquiring of scientific skills and attitudes should be a valid concomitant out-

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[16] Ibid., p. 50. [17] Ibid., p. 41.

[18] National Society for the Study of Education, Science Education in American Schools, 46th Yearbook, p. 150.

come of mastering the subject matter.

The 46th Yearbook and its predecessor have itemized in great detail several sets of specific component objectives under the following headings:

A. Growth in the functional understanding of facts.

B. Development of functional concepts.

C. Growth in functional understanding of principles.

D. Growth in basic instrumental skills.

E. Growth of skill in the use of elements of scientific method.

F. Development of scientific attitudes.

G. Growth in development of appreciations.

H. Growth in the development of interests.[19]

The word "functional" which appears several times in the above outline receives considerable emphasis throughout the entire yearbook. "Science concepts and principles must also be taught so that they will be functional."[20] To ensure this, "once concepts and principles have been meaningfully developed, they should be used and used over and over again ...."[21] Indeed, the same criterion applies likewise to the remaining objectives. "Learning outcomes in science educa-

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[19] Ibid., pp. 28-29. [20] Ibid., p. 26.

[21] Ibid., p. 27.

tion shall function in changed behaviour. We attack mere verbalizations and mechanical skills."[22]

This Yearbook stresses particularly the validity of the more "intangible" objectives of science teaching. Such outcomes as "open-mindedness", "problem sensitivity", "suspended judgment" and the like, which, though less concrete than the 'information' aspects of the program, are worthy and indeed capable of attainment.

> The development of competence in use of the scientific method of problem-solving and the inculcation of scientific attitudes transcend in importance other objectives in science instruction.[23]

However, as worthy outcomes of science instruction they cannot be taken for granted; they will not develop as a natural concomitant of knowledge.

> If these so-called 'intangibles' are to be realized as objectives, they must be sought as vigourously in the classroom as is the functional understanding of facts, principles and concepts.[24]

To reach this end, the Yearbook gives considerable space to appropriate methods.

REPORT OF P.E.A. COMMITTEE

The Progressive Education Association's study entitled Science in General Education published in 1938 is "another

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[22] Ibid., p. 26. [23] Ibid., p. 20.

[24] Ibid., p. 150.

comprehensive statement of the purposes of science in general education."[25] This report considers the needs of youth in a democratic society as the realistic foundation of a modern science program.[26] To this end, the authors have set down four basic areas of living under which student needs may conveniently be categorized. These areas are:

1. Personal living.
2. Immediate personal-social relationships.
3. Social-civic relationships.
4. Economic relationships.[27]

"They are intended to serve as convenient centers of reference for identifying worthy interests and needs and for selecting and organizing appropriate learning experiences."[28]

The study analyzes specific needs appropriate to each aspect and attempts to relate science instruction to their fulfillment. Indeed, this matter of determining valid student needs is vital. "Understandings will be most fruitfully developed by students when, as has been pointed out, they are built in response to needs, problems, inquiries of the student himself."[29]

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[25] Ibid., p. 23.

[26] Progressive Education Association, op. cit., p. 444.

[27] Ibid., p. 27. [28] Ibid.

[29] Ibid., p. 449.

Yet, in the Committee's view, merely meeting these needs may not be enough. They "should be met in such ways as to contribute to the progressive reconstruction and refinement of the democratic way of life."[30] In this fashion, science instruction is not only related to life but to our modern conception of a democratic one.

To organize a curriculum upon this proposed basis of needs, the Committee, as did certain preceding studies, resorts to the generalization of science:

> The Committee has adopted the relatively simple method of formulating the most important generalizations in the field as material suggestive to the science teacher in planning his program.[31]

In suggesting sources of worthwhile generalizations the report sets down several guiding principles. The science teacher is urged to choose interpretative generalizations because these "apply the results of science to the elucidation of problems of wide and rather common human concern."[32] He is cautioned to make certain that the degree of comprehension of each generalization be suited to the purpose of his instruction "The most comprehensive generalizations would be the result of the reconstruction of experiences over a period of years."[33] Finally, he must evaluate all generalizations carefully "to see whether they do actually have promise of

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[30] Ibid., p. 444. [31] Ibid., pp. 449-50.

[32] Ibid., p. 451. [33] Ibid., p. 452.

meeting real student needs."[34]

So far, this book has indicated that student needs should be the basis for choosing science materials and that these materials, if formulated as important generalizations, give the best chance of effective learning. Yet there is still the matter of specific teaching methods. "... it is important to notice that this content can rarely be separated from teaching methods."[35] The science teacher must take pains to organize his learning experiences carefully.

> The science teacher must keep in mind not only the potential science understandings which may grow out of a given learning experience, but also the need for organizing learning so as to achieve the habits, attitudes, specific abilities and skills important in realizing the educational values of a democratic society.[36]

Although the report suggests a variety of suitable learning experiences, it warns that they may be ineffective:

> ...If they are not set in an education framework that will give every adolescent at his own level repeated opportunity to think reflectively, to act on the basis of his own tentative judgments, to behave in ways that he realizes are socially sensitive, coöperative, tolerant, and all the rest.[37]

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[34] Ibid.

[35] Ibid., p. 450.

[36] Ibid.

[37] Ibid.

CHAPTER IV

A REVIEW OF THE LITERATURE: FACTORS IN A MODERN SCIENCE PROGRAM

That the basis for a functional science program is a course of subject matter carefully organized to facilitate the aims of such a program is made clear in the representative studies just reviewed. However, as there is more to a building than the foundation, there is more to a science program than its subject-matter organization. Each of the previous studies, as well as many others in the field, gives attention to various other factors whose importance in science teaching cannot be neglected. If this study is to give a clearer picture of the field under consideration, a survey of opinion in these matters is essential.

Accordingly, this chapter attempts to snyopsize current views on the following: the qualifications of teachers, the equipping of science classrooms, the construction and use of the textbook, the place of experimentation and demonstration, and the scope and purposes of evaluation in science.

1. TEACHERS OF SCIENCE AND THEIR QUALIFICATIONS

PERSONAL QUALITIES OF A GOOD TEACHER

That any successful science teacher must have desir-

able personal qualities can be pretty well taken for granted. Along with his colleagues in other subjects, he should have intelligence, patience, energy, understanding of children, good personality, ability to maintain discipline and to co-operate.[1] Hunter, after stressing leadership, enthusiasm and personality as the "outstanding qualities of a great teacher"[2] admits that no college training can make these qualities; they are part of personality. This study, therefore, concerns itself with those qualifications which a period of training might well be expected to develop.

TRAINING OF TEACHERS

Mastery of Subject Matter

All the sources chosen for this study placed considerable stress upon direct subject-matter mastery as a major basis of teaching competence. "The primary requisite for teaching any course is a sound subject matter background for that course,"[3] declares the 46th Yearbook and goes on to deplore the number of teachers inadequately qualified in this respect. Its predecessor, the 31st Yearbook, likewise

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[1]V.N. Noll, Teaching of Science in Elementary and Secondary Schools, p. 197.

[2]G.W. Hunter, Science Teaching at Junior and Senior High School Levels, p. 526.

[3]N.S.S.E., Science Education in American Schools, 46th Yearbook, p. 58.

has supported this view: "It is impossible to teach any subject well without an adequate background of subject-matter training."[4]

Professional Training

Hunter urges that the subject-matter background be oriented toward high school teaching situations. He points out a danger in traditional university science courses. All college science courses are alike for those going into research, medicine, engineering or teaching. Consequently, teachers have to make adjustments to the pupil's point of view.[5] Although this author is skeptical about the value of traditional subject matter courses in themselves, his objection does not arise from a disbelief in the teacher's need for adequate knowledge. He is concerned with the lack of courses in science organized from the teacher's viewpoint at our college levels. "...Subject matter courses given should provide special training in the teaching of science as well as in the subject matter itself."[6]

Hunter's comments point to a basic concern in the preparation of teachers -- the need for professional courses, i.e. definite training for teaching. This matter is resolved into three aspects:

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[4]N.S.S.E., A Program for Teaching Science, 31st Yearbook, p. 333.

[5]Hunter, op. cit., pp. 513-14. [6]Ibid.

1. Teaching Techniques. The first of these concerns mastery of teaching techniques or methods. "Other things being equal, the more a teacher knows about the teaching process the more effective his teaching should be."[7] The value of a knowledge of the principles of educational psychology and the need for applying them in the classroom is stressed in the 46th Yearbook:

> On the side of instructional techniques, the prospective teacher of science needs an understanding of human growth and of the learning processes, some knowledge of acceptable procedures for measurement and evaluation, some command of the principles of educational guidance, a good deal of help in methods of organizing and presenting the materials of instruction, and as much pre-service experience under competent supervision in actually conducting classroom and laboratory work as can be provided.[8]

This point of view with its insistence upon practical preparation is generally supported by other writers. Noll, notably, suggests a program of training which includes general psychology and professional courses and considerable practice teaching.[9] Hunter deplores the fact that relatively few teachers have had adequate teacher training opportunities.[10] Webb as quoted by Hunter "advocates that

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[7] E.D. Heiss, E.S. Obourn and C.W. Hoffman, Modern Science Teaching, p. 41.

[8] N.S.S.E., 46th Yearbook, p. 285.

[9] Noll, op. cit., p. 211.

[10] Hunter, op. cit., p. 518.

at least forty per cent of the time of the undergraduate course be spent in specific preparation for teaching."[11]

2. Background in Science. The second aspect of teacher training is not concerned with the techniques of teaching but with the broad background that any competent teacher may require. To what extent should a teacher be liberally educated? To what extent should he specialize, and to what extent should he have a grasp of the other branches of science? Each of these questions is answered with varying emphases.

The first of these questions, "To what extent should a teacher be liberally educated?" receives a degree of attention in certain studies. The 31st Yearbook proposes to begin its suggested program of teacher training with a course "built around those generalizations and principles of science that relate most immediately to the needs and interests of liberally educated people."[12] The National Committee on Science Teaching proposes a schedule in which electives such as philosophy and sociology are well represented,[13] and Curtis and Noll recommend some work in the social sciences as providing a suitable "liberal" background.[14]

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[11] Ibid., p. 514. [12] N.S.S.E., 31st Yearbook, p. 340.

[13] N.S.S.E., 46th Yearbook, p. 280.

[14] Ibid., p. 279.

The matter of degree of specialization is also deserving of attention. That a teacher should know his subject well is clearly implied in all studies and several opinions have already been given on this matter in our review of subject-matter mastery. The basic problem seems to be in reconciling extreme specialization with breadth of training within the sciences themselves, and may to a degree be considered apart from the broader implications of a 'liberal education'. After noting the need for thoroughness, the 31st Yearbook continues:

> Another convincing argument for breadth of training is emphasized by the fact that biology, physics and chemistry are so closely related. Qualifications for success in one major field are greatly strengthened by training in related sciences.[15]

Noll states that "the prospective teacher needs both"[16] specialization and breadth of training, and continues:

> It appears then, that prospective science teachers should have some training in all the natural sciences commonly taught in the secondary schools and that some training in a related field like mathematics is also highly desirable.[17]

The Cooperative Committee on Science Teaching in speaking of teachers in smaller high schools notes a particular need for teachers who are broadly trained, yet sufficiently specialized to teach with authority.[18]

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[15] N.S.S.E., 31st Yearbook, p. 335.

[16] Noll, op. cit., p. 208. [17] Ibid., p. 198.

[18] Cooperative Committee on Science Teaching, "The Preparation of High-School Science Teachers," School Science and Mathematics, XLII (Oct., 1942), p. 638.

Indeed we may detect two considerations at work in this matter of specialization: the practical need for breadth of training which enables a teacher 'to turn his hand' to any science if he must, and an idealistic need for breadth which helps ensure a wider appreciation of the whole field of science. In short then, the science teacher must 'know his stuff' as the pupils would say, but not to the point of excluding some knowledge of sciences other than the one he expects to teach.

3. Appreciation of Aims of Science Teaching. The third aspect in the field of professional training relates to the aims of science teaching and the teacher's conception of them. The teacher should have an adequate notion of what science teaching is trying to do; this seems an abvious requisite. That the new emphasis in science teaching makes this doubly true is recognized by the 46th Yearbook:

> The tendency is away from strictly subject-matter bounded courses toward organization around functional areas in the lives of the pupils. This trend is decisive.... and it is important in relation to planning for the education of science teachers.[19]

Modern Science Teaching states, "It makes for clarity in science teaching when the teacher understands the major goals of science teaching...."[20] Hunter may have had something of

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[19]N.S.S.E., 46th Yearbook, p. 276

[20]Heiss, Obourn and Hoffman, op. cit., p. 42.

the same in mind in his criticisms, previously given, of traditional university courses. He continues, "The universities deal with the subject matter of the specialist; the courses of study deal with the subject matter of the child,"[21] and proposes that college science courses taken by teachers be arranged "from a unitary standpoint rather than that of the logical science of the university,"[22] and that these courses be taught by high school methods designed to "produce specific habits, skills and attitudes"[23] -- those qualities which teachers themselves should seek to develop in their own pupils. In short, he advocates professionalized science courses designed for teachers and their work; no longer should the prospective teacher be compelled to study a science organized to train engineers or chemists.

The 46th Yearbook apparently thinks along the same lines for its authors propose in their teacher-training program that "all the science courses suggested, including the survey courses, should provide abundant opportunity to use the scientific method in dealing with important issues and problems."[24] Indeed, this yearbook declares that training

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[21] Hunter, op. cit., p. 511.

[22] Ibid., p. 513. [23] Ibid.

[24] N.S.S.E., 46th Yearbook, op. cit., p. 286.

programs have tended to be too narrow. And, like Hunter, it deplores the frequent practice of teachers taking the same science courses as future chemists and physicists and adding units of psychology and education -- all done "without much or any planning of a program with teaching as an objective of first importance."[25]

In summarizing its comments upon the education of science teachers, this same work lists as two of the three important areas in which science teachers should be competent as: "(a) functional understanding subject matter ... and (c) a social philosophy of science teaching."[26]

These comments suggest that merely mastering subject matter may not be enough for adequate training; the teacher also must acquire definite ideas of what he is expected to do with it.

Length of Training

No discussion of teacher training would be complete without some mention of length of the training period. As this matter is receiving much attention in Canada at present, the opinions of educational writers should prove of interest.

If the type of training mentioned in this discussion is to be adequate, one could assume that the training period must be fairly lengthy; the authors consulted speak directly

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[25] Ibid., p. 281. [26] Ibid., p. 287.

or tacitly of a four or five year training period. Noll intimates that even four years may be too short a time.[27] This author, at any rate, finds agreement among many writers "on the requirement of a bachelor's degree for all teachers of science in secondary schools."[28] The 46th Yearbook quotes an American Association for the Advancement of Science report which considers "a five-year program for the preparation of of science teachers as a desirable future goal."[29]

SUMMARY

In summarizing the opinions gathered from many modern studies, the student of educational trends would note the following major points as receiving substantial support:

1. The teacher of science must have appropriate personal qualities.
2. He must know his subject matter well, yet have received training that provides a balance between over-specialization in one branch of science and superficial knowledge of many.
3. He must be trained to understand children, and to best present his subject to them in the classroom.

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[27]Noll, op. cit., p. 208.

[28]Ibid., p. 204.

[29]N.S.S.E., 46th Yearbook, p. 281.

4. He must have some elements of a liberal education which acknowledges the important social implications of science.

5. He must be aware of the aims of a functional science program and of the means of implementing these aims.

> To teach effectively one must know. But knowing carries far more subtle implications than just knowing science. It means knowing something of the art of teaching, something of the social and economic implications of science; something of the nature of child development and many other things.[30]

2. THE SCIENCE-CLASSROOM AND LABORATORY FACILITIES

FUNCTION OF THE SCIENCE ROOM

Rooms in which science are taught are unusual because "so much attention is given to the physical environment in which effective teaching and learning can proceed."[31] A functional science room, then, is not just another classroom, but one requiring arrangement and equipment governed by the peculiar aims of science instruction. In one representative modern view, science rooms are places "where students may receive educational experiences which are to serve purposes of problem solving and for forming generalizations."[32] It is

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[30]Heiss, Obourn and Hoffman, op. cit., p. v.

[31]N.S.S.E., 31st Yearbook, p. 281.

[32]Ibid., p. 291.

inevitable then, that modern studies on science teaching are concerned with the efficient planning and equipping of science rooms.

VALUE OF COMBINATION SCIENCE ROOMS

"In the past the place of science has demanded a special type of room or rooms where experiments and laboratory work are done and where different types of apparatus ... were stored and used."[33] Hunter also states that "we must have proper laboratory facilities,"[34] but whether or not they should be separate from the science classroom is now disputed. Hunter, himself, suggests that laboratories located in separate rooms "do not lend themselves to modern teaching ...."[35] Indeed, there is considerable opinion favouring a combined laboratory and classroom: e.g.,

> ... A science room should be equipped for general classroom activities, demonstration work, and laboratory work. Such a room will make it possible for teachers and pupils to change quickly from one type of activity to another and thereby provide better coordination between all science activities.[36]

Modern Science Teaching also favours a combination room because such a room "is a much more flexible place to

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[33]Hunter, op. cit., p. 487.

[34]Ibid., p. 486. [35]Ibid., p. 496.

[36]N.S.S.E., 46th Yearbook, p. 240.

carry on activities of a problem solving nature because it enables the class work to be shifted at any time ...."[37]

The adaptability which such a room affords measures up to one of the criteria demanded by the 31st Yearbook: "The plan and design of a science room must provide elements of flexibility."[38]

FURNISHING THE SCIENCE ROOM

With science classrooms "beginning to assume the appearance of general workrooms"[39] which serve "as workrooms, study rooms, classrooms, laboratory rooms and lecture rooms"[40] the flexibility required makes it "advisable to have science rooms equipped with a type of furniture which will provide for all types of classroom activities, demonstration work, and laboratory work."[41]

At any rate, whether laboratories are separate or not, science rooms "should be planned to comfortably and efficiently take care of the optimum class size for instruction."[42] They must be capable of handling all types of learning activ-

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[37]Heiss, Obourn and Hoffman, op. cit., p. 248.

[38]N.S.S.E., 31st Yearbook, p. 293.

[39]Hunter, op. cit., p. 493. [40]Ibid.

[41]Heiss, Obourn and Hoffman, op. cit., p. 248.

[42]Ibid., p. 249.

ities and the furnishing of the room should be directed to this end.

Furniture should be sturdy and arranged to prevent crowding. Experimentation requires good plumbing, gas outlets, plenty of drawer and storage space, fume closets, etc. Book cases and cabinets for supplementary reading materials are desirable. A filing cabinet for storing display materials is also helpful as is a display space for student projects. A large bulletin board and blackboard are necessary.[43]

INSTRUCTIONAL MATERIALS

Besides an efficiently designed working space the science teacher requires certain materials with which to carry on his instruction, particularly in relation to the needs of experimentation and demonstrations.

Modern Science Teaching suggests that the materials obtained should be governed by:

1. Needs for demonstration work.
2. Needs for laboratory work.
3. General laboratory needs, such as tools etc.[44]

The effectiveness of instruction is also enhanced by the following:[45]

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[43] Ibid., pp. 249-252. [44] Ibid., p. 271.

[45] N.S.S.E. 46th Yearbook, pp. 240-2.

As well as serving as valid tools in instruction, wall charts, display posters and the like serve at least to give a scientific atmosphere to the room.

A microscope and even a telescope are well-nigh indispensable in some phases of science teaching. The opaque projector is proving a valuable tool in instruction, and with the ready supply of films and film strips now available, movie and slide projectors are likewise proving their worth.

Science displays with objects, specimens and models are proving valuable in many places. Indeed, any such object that is pertinent to a phase of science being taught should be included. An outstanding example of such devices is the aquarium, a common feature in our science rooms.

With the current emphasis upon pupil reports and committee work, some sort of library is necessary. In addition, a collection of interesting books encourage wider reading of science materials. It is likely, of course, that facilities will vary greatly in this respect. A few supplementary texts, pamphlets and a good encyclopedia can be readily obtained.

SUMMARY

In summarizing the discussions of a number of studies on this matter of classrooms and their facilities, the following points have received a measure of agreement:

1. Science classrooms should be roomy and readily adapt-

able to all kinds of valid instruction.

2. They should contain materials adequate for purposes of experimentation and demonstration.
3. They should contain sufficient display and storage space.
4. They should have charts, models and similar materials.
5. They should contain adequate items of major equipment, such as a microscope, scales, projectors etc., and provide facility for their use.
6. They should have a good supply of reference materials with convenient facilities for their display and accessibility.

3. THE TEXTBOOK -- ITS STRUCTURE AND USE

IMPORTANCE OF THE TEXT

One has only to note the space given to question of textbook construction, selection, and use in many studies on science education to realize the important place the textbook holds in educational thinking. "It is true that in this country ... the textbook has come to play a very important part in secondary education," says Hunter who continues, "In science, although other ways of learning have been considered of more value, the textbook has been and continues to be the basic guide of both teachers and pupils."[46] A recent profes-

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[46]Hunter, op. cit., pp. 231-2.

sional book written for science teachers considers that "the textbook is, in the final analysis, the most important factor in determining what is to be taught in any science."[47] And Reudiger in 1932 has stated, "Textbooks are not inherently out of harmony with wholesome educational conceptions, when properly used, and to follow a textbook is not necessarily evidence of educational incapacity."[48]

The intimation "when properly used" suggests the possibility of a degree of misuse. It may, then, be profitable to consider just what modern authorities consider by proper use. We must also be concerned with the matter of suitable and unsuitable textbooks and what makes them so. Consequently two questions require consideration: What are the qualities of a good textbook? What is the proper use teachers are to make of it? As our modern goals in science teaching seem to be orientated to "functional ends", the standards for textbook selection and use may be likewise related.

BASIC QUALITIES OF A GOOD TEXT

Mechanical Qualities

The durability of the book represents a practical consideration which most authors note without extensive

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[47]Heiss, Obourn and Hoffman, op. cit., p. 66.

[48]Hunter, op. cit., p. 245.

elaboration. Mechanical construction, including such things as: size of print, clarity of illustrations, quality of paper, and attractiveness of format, serves to stimulate interest in the contents, and for this reason receives mention in lists of desirable qualities.

Subject-matter Treatment

The factual information in the book is, of course, a primary consideration. That it should be accurate and up-to-date is generally taken for granted. Accordingly, authors pay more attention to two related factors: the amount of content and the organization of content.

1. Amount of Content. Hunter detects a trend to inflated texts. "Encyclopaedic texts in science seem to be much in vogue just now."[49] The 46th Yearbook concurs with this statement. "It is probably true that every modern textbook of science contains more material than can be effectively taught to any class within the time and with the facilities available."[50]

Hunter's comment upon this trend and its results is pertinent. "... Authors have attempted to meet the demands of already overcrowded courses of study, and in this attempt

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[49]Hunter, op. cit., p. 246.

[50]N.S.S.E., 46th Yearbook, pp. 48-9.

have filled their texts with a surplus of factual material ...."[51]

Hunter's criticism is taken up by others. The amount of material is often unwieldy and, cannot be effectively taught in the allotted time.[52] Attempting to do so "can result only in the stressing of factual material to the neglect of the important objectives of the course."[53] From the viewpoint of functional science this is a serious fault. Too much content and its result are thus deprecated as nullifying the aims of modern science teaching.

2. Organization of Content. The question of the organization of material is likewise an important one. A text written from a definite point of view and with material organized in accordance with it is preferred. "No text in science has a right to be simply a compendium of facts ...."[54] The subject matter in any science text must be organized to encourage development towards those goals the writer considers important. In traditional texts, written to encourage mastery of the facts and the logical structure of science, we can readily note the influence of the older aims of science

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[51]Hunter, op. cit., p. 246.

[52]N.S.S.E., 46th Yearbook, pp. 48-49.

[53]Ibid.

[54]Hunter, op. cit., p. 246.

teaching. As many authors have criticized these traditional aims so do they criticize texts which reflect them. In Hunter we read, "Naturally so long as testing programs and particularly college entrance requirements demand facts just so long will textbooks be written which encourage this wrong point of view."[55] In this regard, Noll is concerned with lack of emphasis upon scientific concerns of every day interest:

> These are sacrificed to the inculcation of the fundamental principles of science, the rock-ribbed postulates that constitute the framework of the subject and which the scientist holds to be the really important things ..., such principles as now presented are often of little interest or value to the high school pupil .... After all, science instruction that does not function in the lives of most persons is for them a wasted effort.[56]

Noll deals at length with this matter. In discussing physics texts he states that one reason for failure of this subject to interest pupils, is "its slowness in following the lead of the newer science subjects in textbook organization."[57] Noll seems to favour the inclusion into physics courses of more material of definite interest to high school students for "the amount of dead material is large."[58]

In biology he commends "a functional treatment with

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[55] Ibid., p. 247. [56] Noll, op. cit., p. 146.

[57] Ibid., p. 137. [58] Ibid., p. 139.

increased emphasis upon the problems arising out of the relationships of living things and especially of man to the environment."[59] Modern Science Teaching also notes favourably the appearance of science texts organized about problems which the pupils are encouraged to solve.[60] After analysing a wide variety of printed material, Pruitt found 135 generalizations, any number of which could be used as a basis for a vitalized high school chemistry course.[61] This investigator suggests that all high school science materials be organized around the most significant of these generalizations. With this point of view Noll seems to concur.[62] The implications of Pruitt's proposal on textbook reorganization are obvious.

Hunter considers all texts as being written from either the logical or the psychological point of view and strongly favours the latter:

> In the psychological organization there will be no logical sequence of the various items studied for they will be presented in the order in which the child naturally uses them in attempting to solve any new problem which is interesting to him. In the logical method of organization we force the mind to follow certain definite steps which result in the memorization of principles or definitions which have little or no application in the lives and

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[59] Ibid., p. 145.

[60] Heiss, Obourn, Hoffman, op. cit., p. 123.

[61] Noll, op. cit., p. 133.

[62] Ibid.

thought of young people working in science.[63]

Johnson, writing in Teachers College Record, considers "a well-defined educational viewpoint in accordance with accepted educational aims"[64] as one of five basic criteria for selecting a text.

Miscellaneous Considerations

There are other, perhaps minor, features that a good text should possess besides those just discussed.

1. Style of Writing. Interest in scientific matter can be encouraged by an author who presents the material compellingly. One has only to note the wide appeal of many books on popular science to realize the truth of this. If the materials can be written engagingly without sacrificing anything to superficiality, the cause of science teaching has gained. Hunter supports this view: "Any texts in science written for the age levels of the junior or senior high school have no reason for existence if they are dull or uninterestingly written ...."[65] So does Modern Science Teaching which considers "the appeal for pupils of the author's style"[66] as one of the factors in textbook selection.

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[63]Hunter, op. cit., p. 249.

[64]Ibid., p. 252. [65]Ibid., p. 246.

[66]Heiss, Obourn and Hoffman, op. cit., p. 66.

2. Aids to Learning. Learning devices may do much to enhance the value of a text and most authors commend their inclusion. These devices involve illustrations, graphs, diagrams clarifying demonstrations and experiments, and additional exercises and problems. In addition we may find more difficult problems and supplementary subject matter together with reference lists as a stimulus to the more intelligent and energetic pupils. Many texts include a glossary of scientific terms and several have summaries or outlines containing the salient points of each chapter. This latter practice, however, is deplored by Hunter who considers such summaries as "easy means for the pupils to memorize the important facts"[67] for examinations.

3. Vocabulary. Noll contends that "there is clear indication that the vocabulary burdens of textbooks are unnecessarily large."[68] The 31st Yearbook quotes a number of studies which support this view, and notes a trend toward simplification which "should be fully encouraged by administrators and teachers."[69]

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[67]Hunter, op. cit., p. 248.

[68]Noll, op. cit., p. 145.

[69]N.S.S.E., 31st Yearbook, pp. 78-9.

USE OF THE TEXT

What do modern writers consider "the very definite place in the education process"[70] which the textbook possesses?

The 46th Yearbook values the use of a good text because it provides "a foundation of minimum essentials common to all the class..., also a definiteness of sequence and of continuity which a course based on miscellaneous reference materials rarely possesses."[71]

Hunter has put down a number of reasons why texts are valuable:

> Texts are followed because they organize materials, because they give basic knowledges, because they help to illustrate syllabi or courses of study, because they make for a certain amount of uniformity in school work .... In addition newer texts supply means of motivation, give the students and teachers helps to classify and apply knowledge, and in better books, they set up problematic situations for the pupil so that he may be habituated in the methods of thinking needed in problem solving as it applies to science.[72]

Teachers, however, are cautioned against the exclusive and slavish use of a single text:

> When a single basal text is the only reference source, there is, of course, the danger that the pupils will come to think of the text as the only source of material and will thus have a distorted

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[70] Hunter, op. cit., p. 233.

[71] N.S.S.E., 46th Yearbook, p. 48.

[72] Hunter, op. cit., p. 232.

conception of its true value.[73]

To overcome this danger, the 46th Yearbook proposes a compromise method "which seems likely to prove most satisfactory".[74] It urges teachers:

> ... To select a basic textbook that provides a good general outline of the course and primary text materials which all the class may be expected to study and then to supplement this foundational material with a variety of materials from other textbooks, periodicals, and reference works.[75]

This use of the text as the focal point of the course is viewed favourably elsewhere. Ruediger, while noting that the experienced teacher may "become superior to any textbook",[76] continues that he may still "get the best results by using a published book as the backbone of his course."[77] [Italics not in the original.]

Modern Science Teaching approves of this approach because it encourages "better learning habits on the part of pupils."[78]

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[73]Heiss, Obourn and Hoffman, op. cit., p. 122.

[74]N.S.S.E., 46th Yearbook, p. 48.

[75]Ibid.

[76]Hunter, op. cit., p. 245.

[77]Ibid.

[78]Heiss, Obourn and Hoffman, op. cit., p. 123.

4. EXPERIMENTATION AND DEMONSTRATION

INTRODUCTION

Like the other important phases of science teaching, laboratory work has been recently subjected to considerable scrutiny. A great number of educational writers, in attempting to put down a set of aims to which laboratory activities should be directed, have critically reviewed the methods, facilities and purposes associated with current laboratory-teaching methods. As well as pointing out shortcomings as they saw them, they have suggested aims and techniques to replace the ones they considered inadequate.

FUNCTION OF LABORATORY WORK

The 31st Yearbook in a comprehensive statement declares that laboratory instruction should have the following goals:-

1. The development of simple laboratory techniques, such as weighing, glass bending, microscope manipulation, etc.
2. Proving and establishing for the pupil himself principles which have long since been well established and generally accepted.
3. Using the laboratory as an instrument for object, or 'thing' teaching ....
4. Using the laboratory for the purpose of developing better understanding and interpretations of the principles of science, as a means of better illustration.
5. To produce training in the scientific method.
6. As a means of possible training in the experimental

solution of the pupil's own problems.

7. The use of the laboratory as a workshop for the study of science problems which arise in the science class or in the life of the pupils.[79]

This list of aims is quoted with approval by Hunter[80] and by Hoffman, Obourn and Heiss[81] in their books on current problems in science teaching.

In more general terms, many authors have stated their views on the function of laboratory work. "The laboratory," states Hunter, "should be a place where teachers and pupils together ask questions of nature."[82] This emphasis upon asking questions is maintained by others. "The laboratory should be a place where a pupil may take a question or a hypothesis and test them under controlled conditions."[83] Science in General Education continues with, "Laboratory work is valuable to the extent that it gives the student a chance to exercise judgment in the solution of problems."[84] This concern with solving problems under scientific conditions suggests that in such activity, laboratory work receives

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[79]N.S.S.E., 31st Yearbook, p. 270

[80]Hunter, op. cit., p. 171.

[81]Heiss, Obourn and Hoffman, op. cit., pp. 118.

[82]Hunter, op. cit., p. 171.

[83]Heiss, Obourn and Hoffman, op. cit., p. 117.

[84]Progressive Education Association, Science in General Education, p. 52.

much of its justification and that any other outcome may be somewhat ancillary to this. "Problem-solving activities are an integral part of science teaching and learning, and the sciences laboratory is a natural place for pupils to engage in these activities."[85]

CRITICISMS OF ACTUAL LABORATORY PRACTICE

Thus concerned with problem-solving as the heart of laboratory work, many writers attack much of our actual laboratory practice as lacking in vitality and purpose.

> Too often laboratory work degenerates into mere busy work on the part of the pupils. Laboratory directions are followed slavishly and without thought and there is little evidence of controlled experimentation.[86]

Noll contends that, "In many cases, the pupil becomes so involved in a mass of detail that he is completely befogged when the laboratory period ends."[87] This criticism echoes Hunter who declares:

> ... Often problems are lost in a maze of mimeographed directions which concerned the making of certain definite measurements or the putting together of certain chemical materials in order to obtain definite reactions.[88]

In such cases, he continues, "Because the relation to the

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[85]N.S.S.E., 46th Yearbook, p. 235.

[86]Heiss, Obourn and Hoffman, op. cit., p. 117.

[87]Noll, op. cit., p. 48. [88]Hunter, op. cit., p. 173.

larger problem was not given, all incentive was lost in such work and the values became purely values of techniques."[89] More specifically, Hunter has indicated four objections to much current laboratory practice:

1. Often 'unled' by the teacher.
2. Written observational work often degenerates into 'busy work' which leads nowhere.
3. Much copying by inferior students.
4. Work is often 'cooked' to meet predetermined requirements.[90]

MAKING LABORATORY WORK VITAL

To vitalize problem solving in laboratory work, to make it more spontaneous and purposeful, would appear to be the major task of the science teacher.

To this end, "pupils need to be given practice in discovering problems, setting hypotheses, and in devising controlled experiments as a basis for verifying or rejecting proposed hypotheses."[91] This is not a vain hope:

> Experience had demonstrated that by wise questioning and suggestion the teacher can get students to state the purpose of an experiment, to suggest the experimental factor, and to plan necessary controls to make the results conclusive.[92]

This source continues: "Using such a co-operative scheme of

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[89] Ibid. [90] Ibid., p. 171.

[91] Heiss, Obourn and Hoffman, op. cit., pp. 167-8.

[92] Ibid., p. 169.

planning experiments with the class will take much of the 'cook book' out of laboratory work and revitalize it ...."[93]

Likewise concerned with training in scientific thinking, Noll advocates a somewhat similar method. He suggests:

> ... That the teacher present a variety of problems to the class; that the individual pupils choose challenging ones; that the pupil and teacher together formulate the problem and the methods for its solution without written or printed directions, and that the initiative rest largely with the pupil rather than with the teacher.[94]

Noll justifies this method with the belief "that the problem method, if properly administered, provides stimulation and motivation to the pupil ...."[95]

The 46th Yearbook sets down a four-point set of criteria designed "to avoid the 'cook book-recipe' type of laboratory work".[96] The following problem solving approaches are suggested:

1. Use laboratory work to give the pupils practice in raising and defining worthwhile problems
2. Conduct laboratory work in such a way that pupils will learn the meaning and use of controls in experimentation.
3. Use laboratory work to test hypotheses and interpret data.
4. Maintain a proper balance between student exploration and teacher guidance.[97]

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[93] Ibid., pp. 169-170.

[94] Noll, op. cit., p. 53. [95] Ibid.

[96] N.S.S.E. 46th Yearbook, p. 235.

[97] Ibid.

Accordingly, the purposeful solving of problems may serve to both enliven laboratory work and give practical training in the scientific method. But, if we are to heed points six and seven in the list of goals quoted beforehand from the 31st Yearbook, problem solving must do even more than this.

In this regard, Science in General Education charges science teachers with the task of helping "the student see how reflective thinking, as practised in the science laboratory, is applicable to other areas of living."[98] To this end, laboratory activity directed toward the solving of problems has value "in the attitudes and habits of reflective thinking it encourages."[99]

The curriculum guide for Science 10 likewise emphasizes this need; it is not enough to know the scientific method; students must also be trained to use it "in new and meaningful situations."[100] "This is one major objective of science education."[101] Teachers are urged to have it clearly before them. Any laboratory program whose values do not extend beyond the

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[98]Progressive Education Association, op. cit., p. 49.

[99]Ibid., p. 317.

[100]Alberta Department of Education, Curriculum Guide for Science 10, p. 15.

[101]Ibid.

schoolroom, can be considered functional only in the narrowest sense.

SUMMARY

The Curriculum Guide, although failing to illustrate specific techniques useful in vitalizing experimental work, does provide a succinct statement regarding the place of laboratory work in the Science 10 program. This statement is an effective condensation of the list of objectives presented before in this work and taken from the 31st Yearbook. For this reason, it sums up comprehensively much of what has gone before in this chapter to form a worthwhile declaration of the laboratory's function in a modern science course.

Laboratory work must be vital and purposeful. It has the best chance of being so when used to solve pertinent problems. In this process laboratory techniques can be learned, ideas and concepts clarified, the scientific method revealed and extended to the lives of the pupils. With a competent teacher in charge -- one who steadily and vigourously directs his work to these ends -- these purposes "above and beyond the activity itself" can be effectively attained.[102]

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[102] Ibid., p. 15.

THE DEMONSTRATION AND THE INDIVIDUAL LABORATORY METHOD

Much discussion has taken place regarding the relative merits of each of these methods. The demonstration, with its saving of time and expense, had lead many teachers to view this method with considerable favour. "Because it is time saving and because it is the least expensive method of utilizing laboratory activities, it is being more widely used in science teaching than ever before."[103] It has, in addition, an element of expediency. "Employed in conjunction with the lecture it may very well become a most efficient method for covering a given section of content in a limited time."[104]

It has other claims to recognition. It is an ideal method of 'thing' or 'object' instruction reinforced by teacher explanation. It can prove very effective "as a device for developing understandings in the pupil for facts, concepts and principles ...."[105] Furthermore, while using the demonstration method, "the teacher is in control of the situation and can thus see to it that the pupil makes all the essential observations."[106]

The 46th Yearbook urges use of the problem-solving

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[103] N.S.S.E., 46th Yearbook, p. 236.

[104] Heiss, Obourn and Hoffman, op. cit., p. 116.

[105] Ibid., p. 116. [106] Ibid., p. 117.

approach in demonstrations as in all laboratory work to the end that "not only will the pupils learn facts and principles of science, but they will also develop an understanding of how a scientist works and thinks."[107] This Yearbook mentions specifically four ways in which the problem-solving approach may be implemented in demonstration work. These are:

1. Demonstrations may be used to raise and define worthwhile problems.
2. Demonstrations may be used in collecting data and developing skill in interpretation of data.
3. Demonstrations may be used to test out pupils' hypotheses.
4. Demonstrations may be used to illustrate the applications of principles.[108]

Yet, despite the great value of the demonstration method, its alternative, the individual laboratory method, has a worthwhile place in a modern science program. The demonstration method, for example, is not so readily adaptable to the development of laboratory manipulative skills. Horton, who investigated this matter, indicates that "where laboratory techniques are concerned individual laboratory work is essential."[109] And Curtis, as quoted in the 31st Yearbook, agrees: "... It is difficult to believe that he [the pupil] will acquire any considerable degree of manipulatory dexterity and skill except through the individual laboratory

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[107] N.S.S.E., 46th Yearbook, p. 238.

[108] Ibid., pp. 237-8. [109] Hunter, op. cit., p. 184.

method."[110]

As Webb's studies have shown, the individual method may be superior in the development of resourcefulness presumably because the student is to a great extent working on his own.[111] Finally, on the matter of remembering what has been done, Van Horne's investigation tended to show "that although the demonstration is better for immediate retention, the laboratory is better for permanent retention."[112]

The question of absolute superiority of either method may, thus, prove impossible to answer. After considering the research on this matter, Hunter writes, "One end result of these researches is to show us that individual laboratory work and demonstration each have a place ...."[113] After surveying studies on this matter, Struitt and Englehart concluded, "No method can be considered to be best in every case. Objectives of teaching, nature of pupils, and facilities of the school, will largely determine which method should be used."[114] The 31st Yearbook acknowledges that "each method offers training in certain knowledges, skills and habits not offered by the other."[115] In particular, it stresses the need

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[110] N.S.S.E., 31st Yearbook, p. 100.

[111] Hunter, op. cit., p. 184.

[112] Ibid. [113] Ibid.

[114] Heiss, Obourn and Hoffman, op. cit., p. 162.

[115] N.S.S.E., 31st Yearbook, p. 106.

for demonstrations where economy and safety are involved (in the case of dangerous or expensive experiments) or where expediency is a concern (in the case of involved and difficult experiments); the value of individual work for acquiring techniques, and the opportunities provided by time-saving demonstration to engage in projects, reading exercises, etc.[116]

Perhaps the most fitting judgment comes from Modern Science Teaching: "It is likely, however, that science teachers will continue to find both laboratory work and demonstrations necessary for good teaching."[117]

5. EVALUATION IN SCIENCE

SCOPE OF EVALUATION

"Like teaching, evaluation must begin with a consideration of the outcomes to be sought."[118] If these outcomes emphasize mastery of facts, then we can assume that testing devices will concentrate upon this aspect of teaching. Likewise, if other outcomes besides mastery of facts are sought in science teaching, the testing devices should attempt to evaluate them as well. This observation is well borne out in

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[116] Ibid.

[117] Heiss, Obourn and Hoffman, op. cit., p. 163.

[118] N.S.S.E., 46th Yearbook, p. 251.

the following statement:

> Any attempt ... to evaluate without regard for the purposes, content and methods of teaching -- any such attempt is artificial, and the consequences are almost certainly misleading.[119]

LIMITATION OF FACTUAL TESTING

As authors have criticized the emphasis upon facts in our science courses so do they attack testing programs which select knowledge of facts alone for appraisal.

> In addition to the mere knowledge of facts gained from the study of science, a large number of other outcomes are usually claimed for it, that constitute a fruitful field for research in testing.[120]

In short, if other aims of science have vaildity -- and modern writers claim they do -- then they too, must be appraised. Hunter's comment is pertinent:

> Most of the testing programs measure the acquisition of facts and for such purposes the tests are valid. But is this acquisition of knowledge the chief end of science teaching?[121]

If this is not so, continues Hunter, "our testing program is not valid, for there has been little or no emphasis on testing for power. Should not our entire concept of a testing program be changed?"[122]

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[119] Ibid.

[120] Noll, op. cit., p. 154.

[121] Hunter, op. cit., p. 412.

[122] Ibid.

FUNCTION OF EVALUATION IN A MODERN SCIENCE PROGRAM

It seems logical indeed, that demands to change our testing program should be made concomitantly with demands for newer emphasis in the objectives of science teaching. Accordingly, Modern Science Teaching sets forth the following as the obligations of an effective, modern program of evaluation:

> ... first, to devise tests and measures that will reveal not only the mastery of facts and principles of a given area, but also a functional understanding of the concepts and generalizations involved; and, second, to devise techniques for revealing growth in certain other outcomes such as the elements of reflective thinking, attitudes, creativeness, personal interest, and social sensitivity.[123]

That this is a complex task the same book does not deny. To appraise growth towards less specific goals "is a far more subtle and involved task than measuring the degree to which a student has mastered the facts of biology or chemistry."[124] Yet, despite this difficulty the task has to be done, for "evaluation must be comprehensive enough to include all outcomes and not merely those outcomes in which learning is more easily assessed (e.g., factual knowledge and mechanical skills)".[125]

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[123]Heiss, Obourn and Hoffman, op. cit., p. 187.

[124]Ibid., p. 187.

[125]N.S.S.E., 46th Yearbook, p. 251.

An adequate testing program must include within its scope all the outcomes of science instruction even the more intangible ones. But has evaluation any values to offer beyond this? An inspection of several studies of this matter reveals that it has!

> A further obligation of an adequate evaluation program, equally as important as the appraisal of achievement, is that of detecting as early as possible, the strengths and weaknesses of students with respect to the objectives or goals of the course.[126]

In this connection, Modern Science Teaching states that testing may "enable the teacher to judge the completeness of learning and to be in a better position to prescribe remedial work...."[127]

This diagnostic function of testing is also noted by Noll, who lists "diagnosis of weaknesses"[128] as one of the chief uses of tests as does Hunter in his list of important values of testing. The latter stresses the diagnostic purpose as being the pupil's responsibility as well as the teacher's. The validity of tests as motivating devices is also recognized here by the same author,[129] as is the way in

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[126]Heiss, Obourn and Hoffman, op. cit., p. 188.

[127]Heiss, Obourn and Hoffman, op. cit., p. 189.

[128]Noll, op. cit., p. 174.

[129]Hunter, op. cit., p. 418.

which tests in themselves can "aid in a review of factual material"[130] and act as "an aid in thinking."[131]

Furthermore, teachers as well as pupils may be evaluated by a good testing program. Conscientious teachers can learn from test results "the efficiency of their own teaching."[132] "A frequent testing program is a stimulus both to teacher and pupils."[133]

Thus, the well-balanced evaluation program has several functions. It provides the 'mark' which school administration renders necessary; it records mastery of science content and appreciation of principles and concepts; it measures growth toward the intangible outcomes of science instruction; it has diagnostic value for pupil and teacher, acting as a stimulus to both.

EVALUATION PROCEDURES

Any discussion on the general theme of evaluation would be inadequate if it failed to consider those devices or procedures which authoritative writers consider valuable. Different purposes will, of course, require different techniques.

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[130] Ibid., p. 414. [131] Ibid.

[132] Hunter, op. cit., p. 414.

[133] Heiss, Obourn and Hoffman, op. cit., p. 190.

A. Paper-and-Pencil Tests.

There are two types of these.

1. Objective Tests. General forms of these are classified as completion, true-or-false, multiple response, matching answers, and so on. These all have the advantage of being clear-cut, readily understood and easily marked. Hunter considers the use of this type as a means of motivation as "one of the latest valid uses of this device."[134] In addition, "the multiple choice and matching types may be made to require some generalizations."[135] Generally speaking, however, objective tests are used for testing facts and "for such purposes the tests are valid."[136]

2. Essay Tests. This type has the advantage of giving the pupil "opportunity to organize and integrate his knowledge."[137] It may "test for thinking as well as facts."[138] However, it also encourages cramming; it is difficult to mark objectively and involves much drudgery for the teacher.[139]

Paper and pencil tests have apparently been misused

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[134] Hunter, op. cit., p. 418.

[135] Ibid., p. 421. [136] Ibid., p. 412.

[137] Noll, op. cit., p. 156.

[138] Hunter, op. cit., p. 416.

[139] Ibid.

so greatly in the past that many authors caution against indiscriminate use of them. These tests have frequently constituted the entire evaluation program either on the assumption that learning facts was the primary outcome of science teaching or that mastery of facts automatically indicated growth in the other outcomes of science instruction. We have already presented opinions that decry the first of these beliefs; as for the latter, that "there is considerable evidence to the contrary"[140] is the comment of Science in General Education. This book continues:

> It is quite clear that written examinations, whether of the essay type or of the objective or 'new' type are not adequate for obtaining all the evidence on the basis of which evaluation should be made.[141]

The 46th Yearbook approves the addition of other devices "for by the use of other procedures they [the teachers] are able to extend considerably and profitably the scope of their evaluation."[142]

A review of some of the suggested 'other procedures' may, then, be profitable.

B. Supplementary Devices.

These are designed "to evaluate other outcomes, such as aspects of thinking and desirable attitudes,"[143] and they

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[140]Progressive Education Society, op. cit., p. 395.

[141]Ibid., p. 394. [142]N.S.S.E., 46th Yearbook, p. 252.

[143]Heiss, Obourn and Hoffman, op. cit., p. 187.

reflect "the possibilities of measuring such things as ability to apply principles in new situations of a science nature."[144] Noll continues, "It has been shown that skills acquired in the laboratory, ability to solve problems, attitudes of a scientific worker, and skill in using the scientific method may be measured also,"[145] as well as retention of facts.

The 46th Yearbook lists several of these methods all of which enable the teachers "to extend considerably and profitably the scope of their evaluation."[146] This yearbook considers the following valuable:

1. Rating scales and check lists.
2. Analysis of work products according to acceptable criteria (apparatus set-ups, notebooks, student collections, committee reports, etc.)
3. Classroom questioning and discussion.
4. Observation of significant behaviour; either
   (a) informal, as in day-to-day classroom or laboratory activities, or
   (b) systematic, as in situations specifically planned to elicit known types of behaviour.
5. Conferences or interviews with individuals or with small groups.[147]

This yearbook also presents a great variety of examples of each type -- examples which "are capable of adaptation to any classroom or laboratory by the teacher who is interested in measuring growth of his pupils with respect to each of the

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[144] Noll, op. cit., p. 162. [145] Ibid.

[146] N.S.S.E., 46th Yearbook, p. 252.

[147] Ibid., pp. 252-3.

various objectives of science instruction."[148]

Modern Science Teaching follows the lead of the 46th Yearbook to the extent of presenting lists of newer techniques and illustrative examples. This book, as well, elaborates a great deal on the need for measuring subjective items as ability to recognize and evaluate assumptions, to distinguish facts from theory, to develop logical proof, etc. In each case the book presents clear examples of appropriate devices.[149]

Science in General Education presents a partial list of procedures which it considers of value:

1. Anecdotal Records by teachers, parents and students.
2. Records by trained observers.
3. Questionnaires.
4. Interviews.
5. Study of student creative products.
6. Students' diaries of reading and other activities.[150]

Like the other studies in this matter, this book presents extensive examples of those types which "have proved ... useful in measuring progress towards the 'non-informational' objectives of science teaching ...."[151]

All studies on evaluation seem to recognize, tacitly

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[148] Ibid., p. 271.

[149] Heiss, Obourn and Hoffman, op. cit., pp. 195-221.

[150] Progressive Education Society, op. cit., p. 394.

[151] Ibid., p. 394.

at least, that their lists of supplementary devices are incomplete and that much work has still to be done in this matter. "Teachers, curriculum specialists, and specialists in the study of adolescents should coöperate with test technicians in devising examinations and other methods of evaluation.[152]

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[152] Ibid., p. 395.

CHAPTER V

PHYSICAL SCIENCE -- THE INTEGRATED COURSE

A. REVIEW OF THE LITERATURE

Background and Definition.

It has been felt by many that growth toward the newer aims of science teaching can be encouraged by suitable organization of the materials of instruction. This concern with subject-matter re-organization has already been dealt with in Chapter III. It is pertinent, however, to review a significant development in this field.

Certain attempts, designed to make science "more practical and functional in the lives of boys and girls"[1], have involved a trend towards "generalized courses planned to meet the more immediate science needs of the common users of science."[2] Noll detects a decreased emphasis upon "specialized science courses in the senior high school"[3] accompanied by efforts to extend "the general science point of view to the upper grades."[4]

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[1]E.D. Heiss, E.S. Obourn and C.W. Hoffman, Modern Science Teaching, p. 24.

[2]National Society for the Study of Education, Science Education in American Schools, 46th Yearbook, p. 139.

[3]V.N. Noll, Teaching of Science in Elementary and Secondary Schools, p. 118.

[4]Ibid., p. 145.

The many forms these attempts have taken are noted by the 46th Yearbook in a review of generalized science courses in the high school. In some cases, the newer course is orientated around the theme of consumership, health and safety, etc. In others, each branch of science is reviewed in turn as in traditional general science. Most highly favoured by this Yearbook, however, are those attempts which, drawing upon two or more of the sciences, "integrate" into one course worthwhile and relevant facts and ideas of each.[5]

A fused or integrated course in physical science, then, is one that selects its materials from two or more of the specialized sciences. In the view of those responsible for the Alberta physical science courses, such a course "implies a reorganization of subject matter and concepts drawn from the whole science field, rather than rejection of the contents of the more familiar specialized science courses--chemistry, physics and geology."[6]

Claims Made for Generalized Courses

The value of these general courses would appear to lie in their attempt to make science more "functional in the every day life of the student."[7] Modern Science Teaching

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[5]N.S.S.E., 46th Yearbook, p. 192.

[6]Alberta Department of Education, Curriculum Guide for Science 10, p. 5.

[7]N.S.S.E., 46th Yearbook, p. 190.

after reviewing many physical science courses concludes that such a composite course "seems to be much more functional than either of the other specialized physical sciences."[8] Indeed, it may be that when the technical requirements of specialized science are removed, there is more scope for dealing with practical or social problems and for giving attention to the more personal or intangible outcomes of science teaching. In this regard, Modern Science Teaching notes in some instances an "emphasis placed on training in the abilities of problem-solving and in the development of desirable attitudes."[9] Noll commends the opportunity such courses give to encourage a broader point of view "in place of that of the chemist, zoölogist, or physicist."[10]

The 46th Yearbook recognizes "the superior possibilities of a composite physical science over the separate traditional chemistry and physics courses in contributing to the aims of general education."[11] The Curriculum Guide also implies a concern with general education in stressing the need "to ignore the artificial boundary between physics and chemistry, for example, whenever related facts and principles

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[8]Hiess, Obourn and Hoffman, op. cit., p. 69.

[9]Ibid., p. 24.

[10]Noll, op. cit., p. 145.

[11]N.S.S.E., 46th Yearbook, p. 191.

may be drawn from both to develop a topic being studied,"[12] and justifies this procedure as being "in keeping with the contribution which science education may make to all students."[13]

Organizing and Selecting the Materials of Physical Science

Educators are still left with the problem of finding the most effective method of integrating various science materials into one coherent course. The 31st Yearbook proposes to organize them about the major principles of science.[14] Noll agrees: "It seems likely that the plan of organizing science content around major generalizations of science has the greatest possibilities of success."[15] Further support for this method comes from the 46th Yearbook: "The content should be planned so as to develop concepts and principles important not only in physics and chemistry but also in other branches of physical science, namely, geology, astronomy and meteorology."[16] The Curriculum Guide for Science 10 likewise views physical science as containing "elementary facts,

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[12] Alberta Department of Education, op. cit., p. 6.

[13] Ibid.

[14] Noll, op. cit., p. 119.

[15] Ibid., p. 120.

[16] N.S.S.E., 46th Yearbook, p. 45.

gathered from physics, chemistry, geology and meteorology, and organized to develop important concepts."[17]

Respecting the selection of subject matter, the 46th Yearbook which approves integration "for the purpose of helping young people gain competency in solving their problems of adjustment in the world of today,"[18] issues a double warning. Firstly, the standard for selecting materials is their ability to aid adjustment in "the experiences and felt needs of daily life."[19] "No subject matter can be justified solely on the ground that it is 'good science' of a traditional sort or because it can be 'presented' in the classroom with a minimum of effort and planning."[20] Secondly, the course must not be made too easy. Some previous courses, particularly those which have omitted laboratory work, have been merely "on the level of effortless entertainment."[21]

In short, physical science must not become a watered-down 'snap course'; if it is to fulfill its task, care and skill are needed both in its construction and implementation. This Yearbook does not minimize the difficulties of this undertaking: "There are obviously grave difficulties in the

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[17]Alberta Department of Education, op. cit., p. 6.

[18]N.S.S.E., 46th Yearbook, p. 192.

[19]Ibid.

[20]Ibid.

[21]Ibid., p. 46.

way of organizing a course in physical science which will prove simple enough for ready comprehension by pupils of limited abilities and still retain the unique intrinsic values attainable within this area."[22] It is confident, however, "that a course of this nature can be evolved which can achieve its desired objectives."[23]

Place of Physical Science in the School Science Program

Designed to the end that science instruction may become "more functional in the everyday life of the student",[24] the physical science course has nevertheless raised doubts over its suitability for students planning to enter college.

For those undertaking non-scientific university work, integrated science courses are considered of unquestioned value. The Harvard Report of 1945 implies "that the generalized physical-science course can be just as valuable for the college-bound student with nonscience interests as for those high-school students for whom secondary education is terminal."[25] This assurance is strengthened by the "disposition of colleges to recognize the physical-science course as a bona-fide college-entrance unit for the nonscience major."[26]

As a preparation for university specialization in

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[22] Ibid.

[23] Ibid.

[24] Ibid., p. 190.

[25] Ibid., p. 191.

[26] Ibid., p. 191.

science, such courses in physical science are not in themselves always considered wholly adequate. While praising "the movement toward the science education of the masses in the generalized science courses,"[27] the 46th Yearbook cautions that "adequate provision for early specialization of selected individuals is also a 'must'."[28] Modern Science Teaching notes a tendency in some quarters:

> ... to believe that the courses in physics and chemistry should be retained much in their present form but offered only to those pupils who plan to go on in some field of science as a profession. This would then leave the course in physical science to take care of the functional needs of the young people not interested in specializing in science.[29]

With this scheme the Education Policies Commission of the National Education Association implies agreement.[30]

There is indication, however, of a compromise. Tower Hill School, Wilminton, Delaware, uses a plan in which the fused physical science course is used as a basis for specialized grade XII courses in physics and chemistry.[31] The twelfth year consists of two equal sections -- one of chemistry and the other of physics. As preparation for this, the fused course is taken in grade XI. This compromise scheme

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[27] Ibid., p. 140. [28] Ibid.

[29] Heiss, Obourn and Hoffman, op. cit., p. 69.

[30] N.S.S.E., 46th Yearbook, p. 191.

[31] Progressive Education Association, Science in General Education, p. 477.

"prepares students for college entrance with the same general background in science as would be obtained from one full year's work in physics and another in chemistry."[32]

In Alberta we will notice the same practice of using fused courses as a foundation for subsequent specialization in the high schools.

Such programs are interesting as attempts to meet the challenge of the 46th Yearbook: "If, however, physical science is to realize its full potentialities, it must be made to serve both as a 'college-preparatory' and as a terminal course."[33]

B. IMPLEMENTING PHYSICAL SCIENCE IN ALBERTA

Introduction

Science 10 does not represent the first attempt to introduce generalized science into grade X. In 1944, a composite course in science had been planned and placed in grade X, only, however, to be withdrawn after its first year.

Despite this earlier venture, Science 10 may be considered as the first major step towards a realization of a functional science program for two principal reasons. Firstly, it was designed to replace entirely the traditional special-

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[32] Ibid.

[33] N.S.S.E., 46th Yearbook, p. 46.

ized sciences of grade X, (chemistry 1 and physics 1). Secondly, it was the initial step in a proposed, consistent revision of the entire high-school science program.

Some insight into the construction and aims of the generalized courses in science is obtained by reviewing the stages of their development. As Science 10 is part of a larger program, we have sketched, in general outline, the overall picture without losing sight of Science 10 itself as a major concern. The information used was taken from the official minutes of both the High School Curriculum Committee and the Sub-Committee on High School Science.

Implementation of Integrated Program in the Alberta Curriculum

In November of 1947, a sub-committee of the High School Curriculum Committee, set up for the purpose of reviewing the aims and organization of secondary science, was directed to prepare a plan for a sequence of units in high-school science. This sub-committee arranged for discussions among teachers regarding the nature of any proposed changes. In 1949, encouraged by "evidence of a more receptive attitude toward integrated science courses in the high school"[34] among many groups of Edmonton teachers, the sub-committee went on record as favouring:

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[34] Minutes of Meetings of Sub-Committee on High School Science, February 25, 1949.

1. The principle of integrated courses in science as best meeting the needs of most students in grades X and XI.
2. The possibility in Grade XII of either continuing with a fused course, or of branching into the specialized fields of physics, chemistry or biology.
3. The planning of courses to develop concepts and principles important to all branches of science.

At this point, the sub-committee anticipated future difficulties. The major problems of organizing materials, and of gaining teacher and public acceptance for the revised courses were recognized. The important part which the basic text plays in the success of any course was stressed along with the vital need for a text which incorporates the ideas of fused science.

With these danger points in mind, the sub-committee laid plans for the tentative organization of a new course.

By April of 1950, a proposed plan for the reorganization of all high-school science was ready. Composite courses in physical science were proposed for grades X and XI, to lead to either a third fused course in grade XII, or to the specialized courses in physics and chemistry. Separate courses in biology were proposed for grades X and XI as a prerequisite to the grade XII composite course only.

Justification was found for these new physical science courses in their purpose "to acquaint the student with the

concepts and principles necessary to his understanding of the world in which he lives."[35] They were to stress the attitudes and skills of science useful in daily living for meeting the demands of intelligent citizenship.

At this point, a trial course, organized on the unit plan was taking definite shape. The units had been tentatively named, and their outlines were well under way. After completion, this course was introduced into the grade X classes of several schools on an experimental basis.

By February 1951, the sub-committee was also concerning itself with the construction of an integrated grade XI course, as well as with the matter of implementing both the grade X and XI courses officially. The securing of an adequate basic text, the preparation of a booklet on the aims of generalized science, and the gaining of teacher support were problems receiving attention.

When the trial course for grade X came up for review in October 1951, favourable response from several of the trial schools was noted. A new unit, "The Nature of Matter", was added as background for grade XII chemistry. The search for a basic textbook ended with the selection of Physical Sciences for Canadian High Schools which was deemed suitable after suggested revisions.

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[35] Ibid., April 1, 1950.

By December of the same year, after provision had been made for continued evaluation and revision, the trial course was authorized for schools beginning in September of 1952. At this time, too, the proposed grade XI course was outlined in rough for its trial.

The integrated course designed for grade XII, having received university opposition, has not been instituted.

Summary

It is interesting to note the following:

1. The attempts to gain teacher opinion and approval for any new course.
2. The concern with the basic textbook as an important foundation for the successful teaching of a course.
3. The desire to create a functional course, i.e. one related to the concerns of citizenship.
4. The concern with important principles and concepts as a focal point for the organization of materials.

C. SCIENCE 10 -- NATURE AND AIMS

Introduction

The Curriculum Guide for Science 10 is the official publication regarding the nature and aims of the course. In addition, it acts as a handbook for teachers to the extent of listing important concepts and understandings, suggesting teaching procedures, giving directions regarding the scope

of experimentation, of evaluation, and the use of audio-visual aids.

A close inspection of this booklet not only gives us a clear picture of the organization and objectives of Science 10, but reveals as well the extent to which this course has incorporated the philosophy of functional science set out previously in a review of the literature.

Objectives of Science 10 and Organization of Materials

1. Science 10, as course in physical science, "implies a re-organization of subject matter and concepts drawn from the whole science field."[36] This procedure is justified because "in keeping with the contributions which science education may make to all students, this organization of subject matter is deemed most suitable."[37]
2. Science 10, as a functional course, proposes to link the facts of science with the concerns of life in a modern society. "The education of youth must provide a basis, not only for understanding and attacking problems within our society, but also for developing some insight into the role of science in the lives of young people."[38]

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[36]Alberta Department of Education, op. cit., p. 5.

[37]Ibid., p. 6. [38]Ibid., p. 5.

3. To this end, the materials of Science 10 are "organized to develop important concepts"[39] from various specialized sciences to form an integrated course.

4. Science 10 considers facts important, but they must be used to "achieve all the objectives of science education,"[40] of which factual knowledge is only one. "Science education must develop habits, attitudes and understandings, over and above the facts of science."[41]

More specifically, experiences in science must help the pupil:

a. To acquire useful facts and information concerning the environment and to develop functional concepts and an understanding of scientific principles.
b. To acquire an appreciation of the scientific, or problem-solving method, and to develop an ability to use it.
c. To acquire instrumental skills.
d. To develop desirable attitudes, interests and appreciations."[42]

The Teaching of Science 10

1. Science 10 consists of six units, each one dealing with a basic theme.

The units are:

(1) The Nature of Things.

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[39] Ibid., p. 6.
[40] Ibid., p. 5.
[41] Ibid.
[42] Ibid., pp. 6-7.

(2) The Earth

(3) Temperature and Heat.

(4) Weather.

(5) Fire and Fuels.

(6) Power from Combustion.

2. The materials of each unit have been selected to contribute, when properly presented, to a major concept. As a guide to teachers, a great number of specific procedures are suggested as a means of developing a number of related understands, whose coordination will result in several generalizations basic to each major concept. "The unit is not complete when the understandings have been achieved. It still remains to draw from the understandings clear enunciations of the Generalizations, and in turn, the central theme, or Major Concept."[43]

A list containing understandings, generalizations, and the major concept, is clearly presented for each unit.

3. Laboratory work is considered to have several functions. Making the student familiar with materials and equipment, and enabling him to gain skill in their use is one; clarifying facts and principles is another. Special emphasis, however, is placed upon the suitability of

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[43] Ibid., p. 12.

experimentation for developing problem-solving abilities. Teachers are urged to give these abilities special concern in their laboratory work, and to encourage their transfer to "new and meaningful situations."[44] Thus, experimentation and demonstration are directed "to achieve some purposes above and beyond the activity itself."[45]

4. Teachers are directed to give attention to the use of clear and precise expression through regularly assigned and corrected written work.
5. Evaluation in Science 10 has a broad scope. It should act as a corrective to the teacher in the sense that it indicates how effective his teaching has been. For the pupil, it must appraise his growth in all directions consistent with the objectives of the course. Teachers are cautioned against testing for mastery of facts alone. They must not neglect the "more difficult, but equally important"[46] task of testing "habits, skills, understandings of concepts and principles, and attitudes."[47] As a guide in this activity, they are referred to Heiss' Modern Methods and Materials for Teaching Science.

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[44] Ibid., p. 15. [45] Ibid.

[46] Ibid. [47] Ibid.

6. No specific directions regarding the use of the basic textbook are given. A fairly extensive list of references is presented, however, of which the basic text is considered primary. It is thus implied that teachers will feel free to use one or more sources, as the occasion demands.
7. Using audio-visual aids is considered a practice "of considerable merit under favorable circumstances",[48] and teachers are urged to build up filmstrip libraries. An extensive list of suitable films and filmstrips, available to teachers on loan is presented.

Place of Science 10 in Alberta High School Science Program

The physical science courses in grades X and XI are deemed to have a two-fold function in that together they are designed to provide the following:

1. A two-year science education of a type suited to all students.
2. A basis upon which any student may undertake grade XII science courses, and thereby satisfy university entrance requirements."[49]

Such an arrangement is designed "to provide science education suited to all, as well as to equip those with special ability to proceed with more advanced science education."[50]

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[48] Ibid., p. 16. [49] Ibid., p. 6.

[50] Ibid.

CHAPTER VI

THE QUESTIONNAIRE AND ITS RESULTS

PURPOSE OF THE QUESTIONNAIRE

As a primary purpose of this study required on evaluation of the classroom situation, a number of Science 10 teachers had to be questioned on numerous aspects of their aims and procedures. To secure essential data, the writer used the most expedient device available, the questionnaire.[1]

The questionnaire was designed to reveal both explicit and implicit information. First of all, it supplied directly a great deal of factual data on a variety of matters. These extended from such items as training and experience of the teacher, or adequacy of classroom facilities to the teacher's use of the text, and his attitudes towards the newer aims. From these, a total picture can be readily obtained by mere tabulation of replies. Consequently, the writer was able to answer quite directly such questions as: What number or per cent of teachers have adequate equipment? What number or per cent of teachers stress vigorous testing? -- and so on.

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[1] Appendix A.

Although much can be learned in this way by totalling raw facts, a broader appraisal of many factors may be obtained by comparing or synthesizing pertinent data from related tables. A broad view of evaluation, for example, could be secured only by using several tabulations bearing on individual aspects of this complex factor. In situations like this, the questionnaire's second use was found.

The earlier chapters of this work reviewed current opinion on many salient aspects of modern science teaching. In considering the results of the questionnaire, the investigator strove wherever expedient to set forth teacher attitude and procedure in the light of this opinion. At all times he attempted to delve beneath superficial statistics without going beyond what the results actually warranted.

CONSTRUCTION OF THE QUESTIONNAIRE

For an adequate review of the classroom situation, a wide variety of questions must be answered. For this reason, the questionnaire deals with the teacher's background, the school organization, the school's equipment, the teacher's ideas of the purposes of science instruction, his methods of teaching and evaluation, his treatment of experiments, and his use and appraisal of the authorized text. In addition, provision was made for frequent personal comments and suggestions.

To reveal attitudes without prying unduly, to indicate a choice of answers without suggesting the appropriate one, to be comprehensive yet not over-lengthy, to reduce involved questions to succinct ones capable of short, direct answers -- these were difficulties which the writer attempted to overcome.

Before the final form of the questionnaire was determined, the investigator drew up several tentative drafts; these were sent out in turn to various Science 10 teachers, with a request for constructive suggestions. Keeping these suggestions in mind, he drew up each time a revised and more realistic version. In this progressive way, the final draft was constructed, and copies multigraphed for distribution.

DISTRIBUTION OF THE QUESTIONNAIRE

Through the co-operation of the Department of Education, an alphabetical list of 220 Science 10 teachers had been secured. These names, representing teachers from all parts of the province and in all types of schools, provided a convenient mailing list for the study. Copies of the questionnaire, each with a covering letter, were then sent out to each teacher as his name appeared on the list. There was no conscious attempt to canvas either certain numbers of teachers on specific levels of training and experience, or certain numbers of schools of specific types, e.g. size, rural, urban, etc.

Of the 230 copies sent out (including the earlier tentative drafts) ninety-seven were returned. This represents a return of 42 per cent. Many were only partially filled in, but a great number were not only complete, and showed as well the teacher's sincere concern with the issues involved.

DISTRIBUTION OF REPLIES

Tables I, II, III and IV set forth the distributions on the bases of: experience of teachers, training of teachers, size of schools, and degree of specialization.

Experience of Teachers

TABLE I.--EXPERIENCE OF TEACHERS

Years of Experience	1	2	3	4	5	6	7	8	9	10 or more
Number of Teachers	11	12	9	10	8	1	7	4	1	33
Per Cent	11	13	9	10	8	1	7	4	1	34

1. The largest single group (34 per cent) had 10 or more years of experience.
2. The second-largest single group had 2 years of experience.
3. Of the teachers answering, 11.5 per cent had only 1 year of experience, which was the one just concluded when they answered the questionnaire.
4. Sixty-seven per cent had 4 years or more of experience.

5. The average amount of experience for the whole group was 7.76 years.

Training of Teachers

TABLE II.--TRAINING OF TEACHERS BEYOND GRADE XII

Years of Training	1	2	3	4	5	6	7
Number of Teachers	1	5	14	39	22	13	3
Per Cent	1	5	14	40	23	14	3

1. All teachers have grade XII or more.
2. The average number of years of training is 4.3.
3. The largest single group had 4 years of training.
4. The second largest single group had 5 years of training.
5. Eighty per cent of all teachers had 4 years or more of training.

Size of Schools

TABLE III.--NUMBER OF TEACHERS IN SCHOOLS OF VARIOUS SIZES

Number of Rooms In School	1	2	3	4	5	6	7	8	9	10 or more
Number of Teachers	18	9	20	13	5	4	5	3	4	12
Per Cent	19	10	21	14	5	4	5	3	4	13

1. Fifty per cent of teachers represent high schools of 3 rooms and under.
2. The largest single group consists of teachers in 3-roomed high schools.
3. Twenty-five per cent of teachers represent fairly large to large schools i.e., those of 7 rooms and more.

Specialization of Teachers

TABLE IV.--DEGREE OF SPECIALIZATION IN SCIENCE

Degree	Number of Teachers	Per Cent
Fully-Specialized	62	64
Semi-Specialized	13	13
Non-Science	22	23
Totals	97	100

Teachers were classified for Table IV on the following basis:-

A. A "fully-specialized" teacher was considered as one who undertook professional training primarily (1) in two basic sciences, e.g. chemistry and physics; (2) or in one science and mathematics; or (3) in one science exclusively, e.g. chemistry.

B. A "semi-specialized" teacher was considered as one who concentrated (1) upon two subjects, one of which is

not a science; e.g. chemistry and philosophy; or (2) upon mathematics alone; or (3) in a semi-scientific field as Industrial Arts.

This group includes, therefore, those who, while not trained for science exclusively, have had continuous scientific or related training at the university level.

C. A "non-science" teacher is one who undertook university work in non-scientific fields e.g. history and French, mathematics and English.

From Table IV we note that:

1. Seventy-seven per cent of teachers have at least some continuous training in science at the university level.
2. Twenty-three per cent of teachers have little if any training in science at the university level.

Summary of Distribution of Replies

On the four important matters of experience, training, specialization, and size of school, the questionnaire replies represent a wide diversity of conditions.

ANALYSIS AND FINDINGS

TEACHERS' QUALIFICATIONS

Chapter IV set down quite definitely the high standards which modern educationists set for teachers of science.[2]

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[2]Chapter IV, Sub-Chapter on Teachers of Science and Their Qualifications, pp. 40-41.

It may be pertinent to review the questionnaire results wherever they have practical bearing on the matter of teacher preparation. The previous tables are used for this purpose.

Length of Training

It has been suggested that at least four years of college preparation was needed for the proper training of a teacher of science.[3] An examination of Table II has revealed that one-fifth of our group fail to meet this standard in various degrees.

Specialization

Considering length of training by itself may be misleading because the training may be in non-scientific fields. In this regard it was noted in Table IV 23 per cent of the teachers had little if any background in science beyond high-school level. Furthermore, these teachers must lack training in methods of teaching science as well.

Summary of Teachers' Qualifications

It appears that the need for teachers with an adequate subject-matter background for science teaching as insisted upon in Chapter IV[4] is not being met in a substantial number of cases. Two circumstances bear on this situation: (1) the presence of teachers trained in non-scientific fields, and, (2) presence of teachers insufficiently trained in any field.

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[3] Ibid., p. 49. [4] Ibid., p. 49.

FACILITIES AVAILABLE FOR SCIENCE TEACHING.

Adequate facilities represent one of the major factors upon which the effectiveness of a science course depends. Although this factor alone does not guarantee efficient presentation, lack of space and equipment could seriously hamper any program, no matter how skilful the teacher or how enlightened the aims.

Chapter IV in the body of the thesis and the questionnaire have both been concerned with many items which collectively represent important means through which a course of instruction is facilitated or hindered. Specifically they are: type of room, laboratory facilities, library available, major equipment, materials for experimentation and demonstration, number of bulletin boards and wall charts. Other related factors which may affect the teaching situation were also included in the questionnaire. These are: size of class, and the presence of other pupils. All of these given above are not of equal importance, and allowance for this fact should be made in any appraisal of them.

The Science Room

In Chapter IV of this thesis the science room was set apart from the ordinary type of classroom.[5] This distinction

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[5] Ibid., p. 50.

was justified because of the peculiar nature of a subject which requires a physical environment to enhance growth toward its particular aims and values. For this reason, then, instruction carried on in a room given over to science instruction exclusively, and containing facilities suited to science learning, was considered desirable.

Table V itemizes the answers to questions bearing upon the nature of the science classroom and some of its appurtenances.

TABLE V.--THE SCIENCE ROOM AND ITS FACILITIES

Question	Yes	Per Cent	No	Per Cent
1. Is there a special science room?	44	46	51	54
2. Can room be arranged for group work?	62	65	34	35
3. Have you a good-sized bulletin board?	66	69	30	31
4. Have you any wall charts?	68	71	28	29
5. Have you a film or slide projector?	90	92	7	8
6. Have you a microscope?	83	87	12	13
7. Have you a suitable science library?	72	77	22	23
8. Are other pupils present?	35	36	61	64

It would appear that in a small majority of cases, science instruction is being carried on in ordinary classrooms. This situation may, in great measure, reflect the large number of small high schools represented in the questionnaire

results, where half of the schools reporting were of three rooms or less. What attempts are being made to adapt these ordinary classrooms to science rooms, and with what success may make a worthwhile investigation in itself. At any rate, these results indicate a situation where teachers may be working under difficulties to improvise a proper setting for their science instruction.

Library and reference facilities have been considered in Chapter IV as valuable parts of the science room.[6] The 23 per cent of teachers who report poor facilities in this respect, may be impeded if they wish to encourage project work or extensive reading.

Approximately one-third of this group do not have convenient physical facilities for group or related work. In this respect at least their rooms lack the degree of flexibility required by Chapter IV for modern science teaching.[7]

Bulletin boards and wall charts are two adjuncts which serve not only as teaching aids, but as means for creating a scientific atmosphere. Almost one-third of the schools reporting are deficient in at least one of these.

Devices for showing films or slides are not taken for granted as valuable parts of our educational equipment. Our

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[6] Ibid., p. 54.

[7] Ibid., p. 52.

group of teachers is well equipped in this regard.

The presence of non-science pupils in the classroom while science is being taught, is included in this section, because it may have a direct bearing upon the effectiveness of teaching. A large number of teachers are compelled to concern themselves, at least indirectly, with other pupils during the science period. This circumstance may often place an added strain upon the teacher.

Laboratory Facilities

No one can deny how vital laboratory work is in any serious course in science. This investigation, therefore, is concerned with both the type of space available for laboratory activities and the adequacy of materials for experimenting and demonstrating.

TABLE VI.--LOCATION OF LABORATORY FACILITIES

Location	Number of Replies	Per Cent
As a special room	49	58
Definite part of classroom	19	22
Improvised	17	20
Totals	85	100

In 68 (or 80 per cent) of the cases recorded, there is definite arrangement for laboratory space. In Chapter IV

of this work many reasons favorable to a 'combination' room were presented,[8] and 22 per cent (Table VI) of our group appear to have such an arrangement.

It is interesting to note that 20 per cent of reporting schools have to improvise their laboratory facilities. This may represent a discouraging situation for the teacher, though if the class is extremely small, the hardship involved may be largely theoretical.

Materials and Equipment for Laboratory Activities

Space in itself would be of little value to laboratory work if materials and equipment are lacking. The questionnaire asked the teachers to state conditions in his classroom in this regard.

TABLE VII.--HAVE YOU ENOUGH MATERIALS AND EQUIPMENT TO DEMONSTRATE AND EXPERIMENT FREQUENTLY AND EFFECTIVELY?

Answer	Number of Teachers	Per Cent
Yes	74	79
No	20	21
Totals	94	100

Thus one-fifth of the teachers reporting consider their equipment inadequate for frequent and effective labor-

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[8] Ibid., p. 50.

atory work.

Summary of Facilities Available

In the above cases we have noticed that in almost every instance there is a sizable minority of classrooms reporting a deficiency. More specifically, these deficiencies in per cent of total replies are listed below.

Lack of special science room	54 per cent
Inadequate library	23 " "
Inadequate facilities for committee work	35 " "
Lack of bulletin boards	31 " "
Lack of wall charts	29 " "
Lack of projector	8 " "
Lack of microscope	13 " "
Improvised laboratory	20 " "
Inadequate laboratory materials	21 " "
Presence of non-science pupils	36 " "

Just how serious any one of these or any combination of these may be in any individual school can only be definitely determined by a thorough appraisal of conditions in that school. A poor library, for example, may be compensated for by excellent laboratory facilities or, the lack of a projector by a stimulating emphasis upon some other aspect of instruction. What is more, the qualities of a resourceful teacher may make up for many an inadequacy in space or equipment. Never-

theless, the deficiencies do indicate areas where the 'cutting down' of any science program may occur.

This 'cutting down' may be most serious in the field of laboratory work where, in each instance, one-fifth of the teachers reported an improvised laboratory or a lack of laboratory materials.

PURPOSES OF TEACHING SCIENCE

As much of the recent literature on the modern aims of science teaching has placed a vigorous emphasis upon the intangible outcomes of instruction (Chapter III), the attitudes of any representative group of teachers upon this matter should be of interest.

Content Vs. Intangibles

Teachers were asked to indicate their opinions regarding priority given to content in their teaching.

TABLE VIII.--IS MASTERY OF CONTENT THE PRIME CONCERN OF SCIENCE TEACHING?

Answer	Number of Replies	Per Cent
Yes	39	44
No	49	56
Totals	88	100

It would appear that in theory, at least, a majority (56 per cent) do not give mastery of content, priority in their teaching.

Table IX dealing with a related question presents a majority of teachers actively concerned with the non-factual products of their instruction. The results in Table IX were compiled from answers to a question which followed a list of common intangible outcomes.

TABLE IX.--DO YOU TEACH FOR INTANGIBLE OUTCOMES DELIBERATELY AND DEFINITELY?

Answer	Number of Replies	Per Cent
Yes	63	69
No	28	31
Totals	91	100

As the majority here is greater than in the preceding question, it may be assumed that among the teachers who stress content primarily, there are many who regard "the intangibles" important enough to warrant active, if secondary, interest.

Reasons for Disregarding the Intangible Outcomes

Those teachers who declared that they do not teach deliberately for the non-factual outcomes, represent about one-third of the entire group. As their reasons are, there-

fore, worthy of attention, they have been itemized below. A number of teachers marked two or more of the items.

TABLE X.--REASONS FOR NOT TEACHING DELIBERATELY FOR INTANGIBLE OUTCOMES

Reason	Number of Replies
(a) Take up too much time for deliberate effort.	9
(b) Too nebulous for effective teaching or evaluation	13
(c) Intangibles are superfluous	7
(d) Will best develop as an adjunct to effective factual teaching; therefore, concentrate on content	25
(e) Their growth is so slow that one year's growth is hardly noticeable	5
(f) Any other reason?	1
Total	60

A little fewer than one-half of the replies indicated at least an indirect concern with the intangibles in their belief that "they (the intangibles) will best develop as an adjunct to effective factual teaching; therefore, concentrate upon understanding of content". The remainder intimate a possible lack of sympathy with their purpose of practicability.

Teaching and Evaluation

Those who taught deliberately for the intangibles, were asked a series of three related questions. This series

was designed to reveal the outcomes sought, the methods used to achieve them, and, finally, the procedures used in evaluating growth in their direction.

A. Outcomes Sought. An inspection of the tabulated replies in Table XI reveals that in the first choices "problem-solving ability (scientific method)" headed the list of desired outcomes, followed by "open-mindedness". An "understanding of the value of science" was third. The remaining choices, namely "problem sensitivity", "critical and suspended judgment", and "scientific interests", are all low as first choices. If we consider the aggregate of the first three choices, "critical and suspended judgment" occupies third place replacing "understanding of value of science". These results are based on a three-fold choice, in order of importance.

TABLE XI.--INTANGIBLE OUTCOMES SOUGHT IN ORDER OF IMPORTANCE

Outcomes	Choices			Totals
	1st.	2nd.	3rd.	
(a) Problem-solving ability (scientific method)	19	12	10	41
(b) Problem sensitivity	3	6	5	14
(c) Open-mindedness	17	11	11	39
(d) Understanding of value of science	12	10	9	31
(e) Scientific interests	4	7	10	21
(f) Critical and suspended judgment	4	14	14	32
(g) Any other?				6

B. Methods of Teaching for Intangibles. Table XII shows that, of the methods used, three of the five choices were almost equally favoured as first choice. These were "trying to develop them through routine teaching", "organizing the course to provide methods of discovering principles and concepts", and, "relating facts to the outside world and the students' place in it".

Also in field of first choices, the device "of adapting experimental work to stress the scientific method" made a lesser, yet creditable showing, while the "giving of projects involving student research and thought" was well down on the list.

TABLE XII.--METHODS OF TEACHING FOR INTANGIBLES

Method	Choices 1st.	2nd.	3rd.	Total
(a) Using routine teaching	17	10	9	36
(b) Stressing the scientific method in experimental work	11	12	9	32
(c) Using thought-provoking projects	5	12	10	27
(d) Discovering concepts through methods using research, critical judgment, etc.	15	7	9	31
(e) Relating facts to outside world	16	16	12	44
(f) Any other?				4

If we consider the aggregate of the three choices, in each case we find that "relating facts to outside world" is the most popular with the others receiving fairly substantial support. One must note as well, that experimental work which is stressed in the Curriculum Guide [9] as a most effective means of encouraging problem-solving abilities is given no exceptional preference here. As this intangible outcome is one of those most highly valued by our group of teachers (Table XI), it may be that the potentialities of laboratory work in this regard are not being fully utilized.

C. Evaluation of Intangibles. The number and per cent of teachers who indicated concern with deliberate evaluation of intangible outcomes are set down below:

TABLE XIII.--NUMBER OF TEACHERS EVALUATING INTANGIBLE OUTCOMES

	Number	Per Cent
Evaluating	74	76
Not indicated	23	24
Totals	97	100

[9] Alberta Department of Education, Curriculum Guide for Science 10, p. 15.

It is interesting to note that the number who attempt to evaluate intangible outcomes is larger than the number who teach for them deliberately.

The questionnaire also asked teachers to indicate a preferential choice from a list of evaluating methods. Their replies are tabulated in Table XIV.

TABLE XIV.--METHODS OF EVALUATING GROWTH IN THE INTANGIBLE OUTCOMES

Method	Choices			Total
	1st.	2nd.	3rd.	
(a) Personal observation of pupil's day-to-day work and attitude	35	16	8	59
(b) Use of rating scales	1	3	4	8
(c) Use of special thought questions	18	16	8	42
(d) Observing pupil when given responsibility	6	21	15	42
(e) By considering marks on formal tests as indicative	3	3	14	20
(f) Any device of your own?				7

This table reveals that of the procedures listed "personal observations of the pupil's day-to-day work and attitude" was the most widely used. The related method of "observing pupil when given responsibility" received fair support.

Summary of Purposes of Teaching Science

An overall inspection of the above tables reveals the following facts:

1. A small majority of teachers (56 per cent) do not consider mastery of content as the prime goal of science teaching.
2. A larger number (69 per cent) teach deliberately for intangible outcomes. We must assume, therefore, that many of those teachers stressing content are, nevertheless, actively concerned with encouraging growth toward intangible outcomes.
3. Many of the 31 per cent who do not teach deliberately for intangibles, believe that they will develop as an automatic concomitant of good academic teaching. These teachers, therefore, display at least an indirect concern with them.
4. The largest group, (76 per cent) evaluate growth toward intangible values. This number presumably includes those of group 3, attempting to evaluate what they believe would develop without direct and conscious teaching.

Those teachers who consciously neglect the teaching of intangibles appear to represent two opinions. One of these believes ordinary good teaching will encourage their growth;

the other seems somewhat critical of their value altogether. Both are contrary to advice in the current literature. Here the validity of the intangible values is forcibly set forth, together with the warning, that they will not be attained without deliberate teaching.[10]

An educator who believes in the paramount importance of non-factual values in a science course may be disheartened by the large minority of our group who value mastery of content more highly. Some reassurance may be offered, however, by the many included in this number who concern themselves enough with intangibles to teach for and evaluate them.

The sub-chapter on "Evaluation in Science" of Chapter IV lists many devices useful in evaluating non-factual outcomes.[11] These include rating scales, appraisal of the results of projects, evaluation of reports, questioning, conferences, and observation both systematic and informal.

Table XIV has revealed that the deliberate evaluation of intangibles relies heavily upon teacher observation, though "thought" questions are used fairly often. Very little use was made of rating scales, a relatively formal device.

Most teachers, however, do use reports, experimental work, projects and the like as supplements to formal tests

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[10]Chapter III, Making the Science Curriculum Functional, p. 36.

[11]Chapter IV, Sub-Chapter on Evaluation in Science, pp. 81-3.

for the purpose of obtaining a student's mark (Table XXVIII). These activities could also represent valid means of appraising the non-informative outcomes.

It is interesting to note that the results of formal tests are used to a relatively small extent in the deliberate evaluation of intangibles. This practice is in agreement with the advice given in the current literature.[12]

THE AUTHORIZED TEXT AND ITS USE

The chapter on "The Textbook" in this work puts down the opinions of various writers regarding the textbook's place in modern science education.[13] Despite the many criticisms of construction and mis-use, it was clear that the text holds no mean position as a factor in science instruction. For this reason, the regard in which the present Science 10 text is held by the teachers, and, equally important, the ways in which it is used, are pertinent matters.

Use of the Text

The questionnaire listed three principal methods of textbook use. These are listed below in Table XV, with the number of teachers who indicated each method as being his own.

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[12] Ibid., p. 76.

[13] Chapter IV, Sub-Chapter on the Textbook -- Its Structure and Use, pp. 54-63.

TABLE XV.--HOW TEACHERS USE THE BASIC TEXTBOOK

Method of Use	Number of Replies	Per Cent
Exclusively and unchanged:	10	11
Re-organized for own convenience:	41	44
As a main point of reference among others:	43	45
Totals	94	100

It is interesting to note that 89 per cent felt free to adapt, re-organize and supplement the text in varying degrees.

Opinions of the Text

But what of the textbook itself? How do the teachers appraise it? The questionnaire gathered teacher reactions to various aspects of the authorized text. Table XVI gives the totals for each of twelve relevant sub-questions.

TABLE XVI.--OPINIONS OF THE BASIC TEXTBOOK

Opinion	Agree	Dis-agree
a. Avoids superficiality.	25	54
b. Challenging to the student	26	54
c. Questions and problems are adequate.	29	58
d. Diagrams are pertinent.	72	14
e. Previews and summaries are good.	74	14
f. Demonstrations are good.	72	15
g. Unit organization is helpful.	79	11
h. Integration is effective	36	31
i. Stresses formal experimentation enough for grade 10.	51	37
j. Well-adapted for instruction in intangible outcomes.	29	32
k. Well-adapted for developing major concepts from subject matter.	37	30

In the opinion of our teachers, then, the favourable features of the text are:

1. Diagrams are pertinent.
2. Previews and summaries are good.
3. Demonstrations are good.
4. Unit organization is helpful.

That the text has many favourable features is indicated by the strong support given to the above qualities.

The unfavourable features are:

1. Does not avoid superficiality.
2. Questions and problems are not adequate.
3. Does not challenge the student.

It may be interesting to segregate the replies of those who state that they deliberately teach for intangible outcomes. This group was thought to be more readily receptive to a text whose subject matter may be organized to emphasize values other than an academic and technical mastery of scientific facts. Table XVII gives a compilation of the group's opinions upon certain pertinent aspects of the text.

TABLE XVII.--OPINIONS UPON CERTAIN ASPECTS OF THE BASIC TEXT BY TEACHERS DELIBERATELY CONCERNED WITH INTANGIBLE OUTCOMES

Opinion	Yes	No
1. Avoids superficiality.	18	39
2. Challenges the student.	18	32
3. Integration is effective.	30	20
4. Well-adapted for instruction in intangible outcomes.	19	23
5. Well-adapted for developing major concepts from subject matter	28	16

It will be noted that the charges of superficiality and lack of challenge are well sustained by this group as well. This group shows a larger degree of satisfaction with integra-

tion in the text than does its parent group, while the text's adaptability for growth in major concepts, receives fairly general approval. A most significant point is presented by item 4, where a slight majority here, as in the larger group, do not consider the text entirely suitable for instruction in intangibles.

Summary of Authorized Text and Its Use

It would appear, however, that if the authorized text can be fairly charged with any deficiency, lack of challenge would be one. A substantial majority of the teachers deplore the superficiality of subject matter, its failure to challenge the student, and the simplicity of the problems. Indeed, a general implication that treatment of subject matter, the heart of the textbook, may be unworthy of a grade X science course can scarcely be avoided.

Indeed, this criticism may be related to the opinions of the course in general, as revealed at the end of the questionnaire, where provision was made for such an appraisal. Here, it will be seen, strong reference to the superficiality of the course, and to the repetition of grade IX materials, holds the day. To the extent that an authorized text is "the most influential factor in determining what is to be taught in any science"[14] these unfavourable opinions may, to

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[14]Heiss, E.D., Obourn, E.S. and Hoffman, C.W., Modern Science Teaching, p. 66.

a considerable degree, be indirect reflections upon the basic textbook as well.

With the exception of sub-item i in Table XVI, where a fair surplus of teachers approve the degree of stress upon formal experimentation, the remainder of the sub-items do not show a great deal of opinion one way or the other. This may indicate that the text is fair or mediocre in these respects, and thus avoids a concensus of opinion entirely favourable or otherwise.

The fact that 89 per cent of the reporting teachers are re-organizing and supplementing the text in varying degrees, may indicate that a great many are attempting to follow the method which the 46th Yearbook considers "likely to prove most satisfactory".[15] In this connection, a basic text is supplemented with a variety of materials from other sources, to create the science course. This method, however, may owe much of its success to the basic text. With so many teachers critical of certain important qualities of the present Science 10 basic textbook, it may well be that it is not the best possible choice.

The text may be considered from yet another important aspect, that is, organization and point of view. This task

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[15] National Association for the Study of Science, 46th Yearbook, p. 48.

becomes more pertinent when we consider the emphasis placed in Chapter IV upon the value of having a text written from a "well-defined educational viewpoint."[16] In the relevant matters of effectiveness of integration and of adaptability for evolving major concepts, the text received fair but not overly substantial support. Regarding its adaptability for the teaching toward intangible outcomes it does not fare so well, receiving only minority approval from both the group as a whole and for the segregated group. This latter circumstance, in view of the stress upon non-factual aims in the current literature, may indicate yet another possible shortcoming.

EXPERIMENTATION AND DEMONSTRATION

Extent of Use

The important place that experimentation and demonstration have in the science program is reflected in the results of this survey as shown in Table XVIII. Here it is indicated that 91 per cent of the teachers polled utilize these two related aspects of laboratory work to a substantial degree.

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[16]Chapter IV, Sub-Chapter on The Textbook and its Use, pp. 58-61.

TABLE XVIII.--EXTENT TO WHICH TEACHERS EXPERIMENT AND DEMONSTRATE

Degree of Activity	Number of Replies	Per Cent
Constantly.	24	27
Often.	58	64
Rarely.	8	9
Totals	90	100

For the 9 per cent who answered "rarely" a reason was sought from the remainder of each questionnaire. Here definite impediments such as lack of time, inadequate facilities or equipment were found to be present in almost all cases.

Pupil Participation

The following table tabulates the results of ninety-three replies to the question which dealt with this matter.

TABLE XIX.--EXTENT TO WHICH PUPILS ARE ABLE TO EXPERIMENT AND DEMONSTRATE BY THEMSELVES

Extent of Participation	Number of Replies	Per Cent
Frequently	24	26
Somewhat	29	31
Rarely	36	39
Never	4	4
Totals	93	100

Altogether, it will be observed, 57 per cent of the number permit pupils to participate to a fair extent or better, while 43 per cent permit participation rarely or never. In an attempt to discover the reasons behind this latter figure, the questionnaire of each teacher so answering was examined. The following table sets down the results of this investigation.

TABLE XX.--REASONS FOR PUPIL NON-PARTICIPATION IN EXPERIMENTAL WORK

Inadequacy of space -- equipment -- materials	No Physical Impediment Obvious	Total
17	19	36

One can only surmise why the 19 teachers curtail pupil experimentation and demonstration. Perhaps many feel that these activities are too awkward and time consuming; others may be faced with some insufficiency in facilities which the questionnaire does not directly reveal.

Purposes of Laboratory Work

The writer attempted to learn what purposes our group of teachers have in mind while undertaking laboratory work. Provision was made for an indication of relative choice among a group of common outcomes. Table XXI sets forth the results.

TABLE XXI.--PURPOSES OF LABORATORY ACTIVITIES

	Choice			Total
	1st.	2nd.	3rd.	
a. to establish scientific principles.	37	15	8	60
b. to illustrate principles already taught.	29	24	7	60
c. to give pupils manipulative skill.	3	5	8	16
d. to enable pupil to do work on his own.	4	4	4	12
e. to illustrate 'formal' method of scientific investigation.	0	8	12	20
f. to train pupil in orderly work.	1	9	6	16
g. to present a method of investigation to carry over into life	5	3	14	22
h. as one good means of getting a mark.	0	0	0	0
i. to train pupil in careful observation.	4	14	21	39

As a means of illustrating and enriching scientific principles, experiments and demonstrations find their most common use. This is shown in the relatively great support given to sub-items (a) and (b). Both receive support as first and second choices. "To train pupil in careful observa-

tion" is favored as a third choice. The useful purpose of "getting a mark" is scarcely recognized, overtly at least, as a valid primary outcome.

Summary of Experimentation and Demonstration.

It may be interesting at this point to refer back to Chapter IV of the body of the thesis in which we quoted seven comprehensive goals of laboratory work as conceived by the 31st Yearbook.[17] Two of these goals were concerned with the forming and enriching of scientific principles. That a great number of teachers polled share these goals is clear.

Two other of these goals may possibly be taken for granted in experimental work. These are the ones concerned with "object" instruction and "manipulative" skill. In view of the large per cent of teachers engaging in laboratory work and in many cases permitting their pupils to participate, it may be assumed that these two related goals are, incidentally at least, receiving a measure of attainment.

The remaining goals in the 31st Yearbook's list deal with training in the scientific method and its application to problems both scientific and personal. Using laboratory

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[17] Chapter IV, Sub-Chapter on Experimentation and Demonstration, pp. 65-66.

activities "to illustrate the formal method of scientific investigation" does not make a creditable showing until the third choice, and, even here, it is outranked by two other items. The related "to present a method of investigation to carry over into life" is likewise pretty well disregarded until the third choice where it places second. One must assume, then, that outcomes relating to problem-solving ability are of secondary concern in most laboratory work.

This contention is strengthened by a reference to Table XII METHODS USED IN TEACHING FOR INTANGIBLES, where it is shown that experimental work is not a primary means used for encouraging growth toward intangible outcomes among those teachers actively concerned with these aims. Yet these same teachers esteem the ability "to solve problems scientifically"; this is indicated by this purpose's leadership in Table XI INTANGIBLE OUTCOMES SOUGHT IN ORDER OF IMPORTANCE.

Possibly many teachers, involved in "routine" experimentation, are ignoring or taking for granted what contribution the laboratory can make toward training in vital problem solving ability; others, as intimated in Table XX, may be too impeded by restrictions of materials, space and time to make effective use of laboratory work for this purpose.

EVALUATION

Importance of Testing.

The importance that testing has in the science programs of our group of teachers is indicated by the 90 per cent who test constantly.

TABLE XXII.--DO YOU REGARD CONSTANT TESTING AS A VITAL PART OF YOUR PROGRAM?

Answer	Number of Replies	Per Cent
Yes	82	90
No	10	10
Totals	92	100

Frequency of Formal Testing.

That consistent formal testing is a well established procedure is indicated by the results shown in Table XXIII.

TABLE XXIII.--FREQUENCY OF FORMAL TESTING

Answer	Number of Replies	Per Cent
At regular intervals:	13	14
At end of convenient amounts of work:	49	53
Both:	30	33
Totals	92	100

Associated with the above are 'comprehensive' tests e.g. those given at Christmas and Easter to cover work taken over a fairly long period. In this regard, the replies again indicate a majority favourable to this practise. (Table XXIV).

TABLE XXIV.--DO YOU GIVE COMPREHENSIVE TESTS?

Answer	Number of Replies	Per Cent
Yes	77	85
No	14	15
Totals	91	100

Purposes of Tests.

After determining the frequency and extent of testing, it may be pertinent to learn the reason teachers have for this activity. They were asked, therefore, to state in order of preference those purposes which guided their testing program.

TABLE XXV.--PURPOSES FOR WHICH TESTS ARE GIVEN

Purpose	1st.	2nd.	3rd.	4th.	5th.	Total
a. To get a mark for the pupil	6	6	13	14	19	58
b. To diagnose difficulty	22	27	13	11	2	75
c. To determine mastery of content	36	23	16	2	2	79
d. To motivate the pupil	15	15	26	13	3	72
e. To indicate growth in intangibles	2	7	9	16	18	52
f. Any other reason?						6

An examination of Table XXV reveals that:

1. Determining mastery of content appears to be the most favoured reason for giving tests.
2. Diagnosis of difficulties receives considerable support as a second choice.
3. Motivation of pupil is a strong third choice.
4. Utilitarian purpose of 'getting a mark' is recognized as useful only in the latter choices.
5. Revealing growth toward intangible outcomes is considered of least importance.

Testing for knowledge of facts is thus the most frequent reason for using tests. It may be well to learn what type or types of questions are proving most useful in this regard.

TABLE XXVI.--RELATIVE IMPORTANCE OF VARIOUS TYPES OF QUESTIONS IN TESTING MASTERY OF CONTENT

Type of Question	Choices			Totals
	1st.	2nd.	3rd.	
a. Short question-and-answer	59	16	5	80
b. Fill-in-the-blanks	18	25	12	55
c. Completing or drawing diagrams	5	22	23	50
d. Problems	17	16	25	58
e. Multiple choice	7	15	9	31
f. Essay type	6	4	11	21
g. True-or-false	5	3	7	15
f. Any others?				4

The "short question-and-answer", "problems", and "fill-in-the-blanks" types are favoured in that order with the remainder receiving increasingly less approval.

Despite the great reliance upon formal tests it may be pertinent to learn whether or not our group of teachers use this device alone or whether some supplementary means are also employed in the evaluation program. Table XXVII indicates the results of an enquiry.

TABLE XXVII.--EXTENT TO WHICH MARKS ARE GIVEN FOR WORK OTHER THAN PERFORMANCES ON FORMAL TESTS

Answer	Number of Replies	Per Cent
To a great extent:	15	16
To a limited extent:	73	80
Never:	3	4
Totals	91	100

An overwhelming majority (96 per cent) rely, therefore, upon other means in various degrees to supplement the results of formal tests in determining the pupil's mark. The following table points out the relative uses of some important 'other means'.

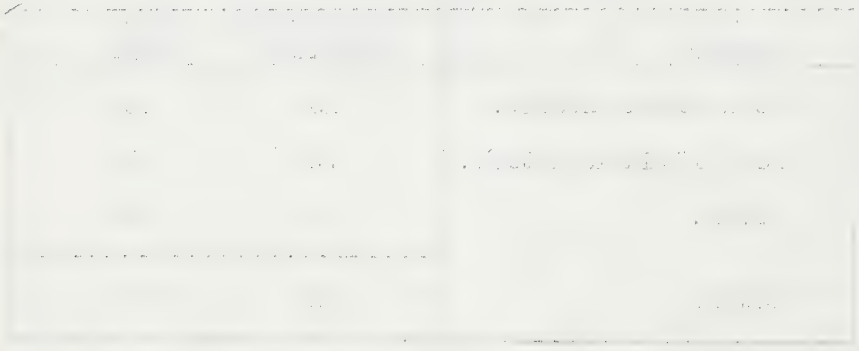

TABLE XXVIII.--SOURCES OF MARKS OTHER THAN FORMAL TESTS

Sources	Number of Replies
a. Reports -- individual or committee	55
b. Performance on experimental work	61
c. Notes	52
d. Work done on projects	50
e. Attitude towards work in general	50
f. Others?	2

The computation of the final mark for the year is our next concern. Teachers were asked to indicate which one of three main procedures they used. The results are as follows:

TABLE XXIX.--COMPUTATION OF THIS FINAL MARK FOR THE YEAR'S WORK

Method	Number of Replies	Per Cent
a. From a single end-of-term test	0	0
b. From several major tests spread over the term	13	14
c. From several factors taken together - tests - notemaking - attitudes - appraisal of student's work on projects, etc.	83	86
Totals	96	100

It is interesting to learn that not one teacher in the group used the 'all-or-nothing' method of a single test. Furthermore, it may be significant that 83 teachers (86 per cent) considered other activities as well as test results in reaching their final appraisal.

Summary of Evaluation

The sub-chapter on "Evaluation" in Chapter IV undertook to set forth the broad scope that evaluating procedures have in the modern science program. More specifically, it was stated that an adequate testing program must be concerned with:

1. Mastery of content.
2. Diagnostic opportunities.
3. Motivation.
4. Getting a mark.
5. Growth towards intangible outcomes.[18]

An inspection of the tables given above reveals that:

1. Testing is considered of great importance with formal tests being given regularly. In these tests a variety of questions is used to determine mastery of content.
2. The first three of the above aims concern teachers more often in their formal testing.

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[18]Chapter IV, Sub-Chapter on Evaluation in Science, p. 79.

3. "Getting a mark", is not considered overtly as an aim of great importance in routine testing.
4. Most of the teachers reporting supplement formal tests with other means for the purpose of getting marks for the pupil.
5. The final or year's mark is in most cases computed from several factors of which formal testing is one.

The matter of evaluating growth toward the intangible goals was discussed in the section on "Purposes of Teaching". To include this aspect of evaluation in the overall picture with the above conclusions we again note:

1. That a majority of the reporting teachers do attempt, in varying degrees, to include the intangibles in their evaluating programs. (Table XIII).
2. That much of this evaluation may possibly be of a casual and informal nature. (Table XIV).

COMMENTS ON THE COURSE IN GENERAL

The teachers were asked at the end of the questionnaire to add any personal comments upon the course in general. Fifty-three teachers were interested enough to do this.

Of these fifty-three, forty-seven presented comments which were generally unfavourable.

Almost all of the favourable comments praised the course for its value as general background and overview of the field of science, particularly for non-college, or non-

scientific students. Indeed, beyond this, there is no other favourable observation worth recording.

Among the adverse comments, a wide variety of criticisms were made. From a total of 66 individual remarks of this nature, 47 stated that the course was "not challenging", was "too general", and the like. Eight of these 47 deplored, especially, the poor basis it provides for grade XII work.

A further 12 teachers were concerned with the "needless" repetition of grade IX work. The remainder were troubled by what they considered inadequate treatment of chemistry or mathematics.

It may be significant that more criticisms were received than marks of approval. Possibly the dissenting teachers felt more strongly than the others, who are, perhaps, satisfied or partially satisfied. It should be kept in mind, at any rate, that almost half the teachers put down no general appraisal at all.

As the basic text frequently served as the foundation of the course, it is pertinent to note once more the opinions of the textbook. One readily observes that the major criticisms of the text, ("unchallenging", "superficial"), are the very ones also most prominent in the general appraisal of the course.

The questionnaire also made provision for a comment upon integration in science. The aggregate comments are

summarized below:

TABLE XXX.--OPINIONS OF THE INTEGRATED COURSE

Opinion	Replies
a. tends to be superficial.	44
b. by destroying the logical framework of specialized science, it lessens the value of science instruction.	29
c. is well adapted for growth towards the intangible ends.	11
d. helps in growth of meaningful concepts by making the facts more meaningful.	17
Total	101

It is apparent that this group of teachers is critical of the integrated course. Whether they oppose integration on principle or whether they merely are censorous of integration as represented by Science 10, is not indicated. At any rate, out of 101 comments, 73 are unfavourable. It may be pertinent to note the repetition of the charge of superficiality.

A question may arise regarding the suitability of many teachers in the above group. Does the group not contain many teachers poorly qualified for science teaching and thus incapable of a valid opinion?

Accordingly, those teachers having at least four years of training as science specialists and also at least four

years of experience in high-school science were taken from the larger group. The opinions of this group on both the course in general and upon integration are considered in the two following tables.

TABLE XXXI.--GENERAL OPINIONS OF THE COURSE BY SPECIALIZED AND EXPERIENCED SCIENCE TEACHERS

Type of Opinion	Number of Replies	Per Cent
Favourable:	7	23
Unfavourable:	24	77
Totals	31	100

TABLE XXXII.--OPINIONS OF THE INTEGRATED COURSE BY SPECIALIZED AND EXPERIENCED SCIENCE TEACHERS

Opinion	Number of Replies
a. Tends to be superficial	17
b. By destroying the logical framework of specialized science it lessens the value of science instruction	15
c. Is well-adapted for growth towards intangible ends.	8
d. Helps in growth of meaningful concepts by making facts more meaningful	6

An inspection of the last two tables indicates that a generally unfavourable view of the present course is taken by the more highly-trained and experienced science teachers in our

group.

CONCLUDING COMMENTS

Although the opinions considered in this chapter come from teachers in pretty well every teaching situation, the entire group represents only a relatively small number of all Science 10 teachers in Alberta. The writer, therefore, wishes to reiterate the need for a circumspect appraisal of the conclusions presented. These conclusions are not absolute and final. They may serve, nevertheless, as guideposts to possible strengths and weaknesses in the course and in its presentation. As such, they may be helpful as starting points for: (1) any teacher's personal evaluation of the course, and (2) any official re-appraisal of materials and organization.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTORY

This study has resulted in a number of conclusions. Many of these are already listed in the summaries which follow each group of tables in the previous chapter; others have arisen from other aspects of the study.

It may be expedient to re-emphasize the more important of these conclusions by stating them in generalized form. In this manner, they may be seen together freed from detail.

The validity of each conclusion, of course, depends upon the validity of the data upon which it is based.

Wherever any conclusion indicates a possible shortcoming in the course or in its presentation, the writer has ventured to suggest a possible means of improvement. Accordingly, the list of conclusions is followed by a list of related recommendations.

CONCLUSIONS

1. Many attempts have been made during the past few decades to free science instruction from its traditional emphasis upon rigidly academic and college-preparatory objectives. Educational reformers have contended that science, as

a school subject, is most worthwhile when teaching is directed towards the development of competent citizenship in its broadest sense. Accordingly, new programs of science instruction have appeared. In these, concern with the growth of attitudes and abilities directly useful in everyday living has taken the place of concern with the training of the specialist. Those programs have been designated collectively as "functional science".

2. Integrated physical science, in which materials from a number of specialized sciences are organized for a purpose other than the mastery of specialized content, is an important development in this field.
3. Developed as a course in integrated physical science, Science 10 was the initial and significant step in the establishment of a program of functional science in Alberta.
4. In attempting the difficult task of inaugurating a physical science program for Alberta's high schools, the creators of Science 10 have been:
   a. aware of those trends in educational thought concerned with making science instruction functional.
   b. concerned with many of the difficulties attendant upon the construction and acceptance of such a program.

5. There is evidence that a great many teachers view the present course in Science 10 unfavourably. Criticisms involving the related charges of generality, lack of challenge, repetitiousness and superficiality appear persistently, and are not counterbalanced by similar expressions of commendation. It is difficult, therefore, to ignore the possibility of Science 10 being a somewhat weak course in integrated physical science.
6. The high standards of professional preparation demanded by the current literature for teachers of high-school science are not being met in a fairly substantial number of cases. This situation is especially noticeable where Science 10 is being taught by teachers trained in non-scientific fields.
7. While many specific qualities of the basic textbook receive general approbation, a large majority of teachers consider the text superficial, unchallenging, and poorly supplied with stimulating questions and problems. In this regard, the principal criticism of the basic textbook parallels the criticism of the course in general. This may be a most significant point in view of the Sub-committee's concern with the need of a basic textbook as the basis for a successful course.

It is likewise pertinent to note that a small majority of teachers do not consider the basic text well adapted

for instruction in the intangible outcomes while rather large minorities consider ineffective both the integration of materials and their adaptability for developing major concepts.

8. In general, the basic textbook is not used slavishly. Most teachers re-organize and supplement its content in varying degrees.

9. Certain deficiencies in facilities and equipment appear consistently. Of these, an inadequacy of laboratory facilities and materials may prove the most serious.

10. Evaluation in Science 10 appears to be particularly vigourous with regard to formal testing. Most teachers, however, supplement formal factual testing in various degrees with other means of appraisal whose results are included in the year's mark. The conscious evaluation of intangible outcomes concerns three-fourths of the teachers although there is some intimation that the methods used may lean to the casual and unsystematic.

11. Most teachers experiment and demonstrate frequently, with a lesser number permitting at least a fair degree of pupil participation. Laboratory work is carried on for a number of conscious purposes, notably the clarification of scientific principles. Performance on experimental work also serves as an important supplement to formal testing in the evaluating program. There is

reason to assume that the potentialities of experimental work in the developing of vital problem-solving abilities are not being fully utilized and that the laboratory programs of certain teachers are somewhat restricted by lack of adequate time or facilities.

12. There is strong adherence to teaching primarily for mastery of content with a large minority of teachers taking this position. Nevertheless, over two-thirds of all teachers do have some deliberate regard for the non-factual outcomes, either as a primary or secondary concern in their teaching. The remainder tend to ignore the intangibles as such in their teaching. A good majority of teachers, including many who do not directly teach for intangible outcomes, attempt, nevertheless, to evaluate their growth. There are indications, therefore, of a certain lack of unanimity among teachers regarding the place and the practicability of teaching and evaluating the non-factual objectives.

RECOMMENDATIONS

1. Greater efforts should be made to assure that, as far as possible, only those properly equipped as teachers of science, are placed in charge of Science 10 classrooms.
2. Greater efforts seem necessary to mitigate many of the deficiencies of equipment and facilities. Some, or all,

of the following may be helpful:

a. An official science-room inventory, to be filled in by all science teachers, would pin-point specific shortcomings as a guide for the teachers concerned, as well as giving the Department of Education an accurate picture of the situation.

b. An official catalogue listing suitable equipment, its approximate price and availability, would enable teachers or school officials to secure more readily any required item.

c. To meet the problem of inadequate libraries, a similar catalogue should be prepared for those attempting to remedy this deficiency. A system of "package deals", may prove effective. Parcels of suitable books, of various sizes and prices, according to the needs of each school, could be prepared under the guidance of the Department of Education. Each package should include subscriptions to two or more suitable scientific magazines.

d. A section of the Curriculum Guide, listing methods of creating a scientific atmosphere in the classroom, would be a boon to the conscientious teacher, particularly, if he is using an ordinary classroom. This section should include directions for the best use of bulletin boards, charts, etc.

e. Some sort of specific directions should be given to teachers hampered by inadequate laboratory facilities. These directions should concern best use of available space, effective improvization, and related matters.

f. Some sort of official science kit may help to overcome the shortage of laboratory materials. These packages would include basic materials for schools of various sizes.

3. Attempts to direct teachers somewhat unconcerned with clear, deliberate teaching for intangible outcomes should be made by:

a. setting down more graphically in the Curriculum Guide the specific nature and value of non-factual outcomes.

c. stressing more vigourously that these outcomes will most likely appear if they are deliberately taught for.

4. The Curriculum Guide should include a section on definite methods of organizing materials for instruction in the intangibles. Subject matter from the course might well be used for this purpose.

5. The need for purposeful evaluation of intangible outcomes seems to require emphasis. In addition, a number of ready and relatively specific methods of evaluation should be listed as a guide to all teachers, and particularly to those whose evaluation may be somewhat casual or uncertain.

6. More specific guidance regarding use of laboratory work

as a means of training for problem-solving abilities, seems in order. Methods of encouraging the use of the scientific method in The Curriculum Guide's new and meaningful situations would be particularly helpful to those teachers having difficulty in this respect.

7. As the course outline and the basic textbook share responsibility for any charge of weakness made against Science 10, they may be profitably reviewed together in relation to the following questions:

   A. The Course:

      1. Is it too long and too general?
      2. Does it repeat too many grade IX materials?
      3. Are many sections too easy?
      4. Is it doing its full share in providing a proper basis for grade XII work?
      5. Are its materials selected and organized to best provide a highly effective course in integrated physical science?

   B. The Basic Textbook:

      1. Are its materials organized most effectively to:
         a. provide efficient integration of subject matter?
         b. encourage ready development of major concepts?
         c. encourage substantial growth toward the non-factual objectives of science teaching?

2. Do the problems and questions generally lack challenge?

d. Is its content often presented in too superficial and unchallenging a fashion for grade X?

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APPENDIX A

APPENDIX A

QUESTIONNAIRE

I TEACHER'S BACKGROUND:

a. Years of training beyond Grade 12 _____

b. Subjects specialized in _____

c. Years experience in teaching senior high school science _____

d. Is science your main teaching subject? (yes no)

II SCHOOL ORGANIZATION AND CLASSROOM FACILITIES:

a. Number of rooms in the senior high school _____

b. Average size of your Science 10 classes _____

c. Time spent per week on Science 10 _____

d. Are other pupils present when this subject is being taught? (yes no)

e. Is there a special science room? (yes no)

f. Location of laboratory facilities. (as a special room, as a definite part of the classroom, improvised)

g. How is your science library? (adequate, fair, poor)

h. Can your room be arranged for committee and other group work? (yes no)

i. Have you a film machine or slide projector? (yes no)

j. Have you a microscope? (yes no)

k. Please name any other major equipment _____

l. Have you enough materials and equipment to demonstrate or experiment frequently and effectively? (yes no)

m. Have you a good sized bulletin board? (yes no)

n. Have you any wall charts? (a lot, a few, none)

III EVALUATION AND METHODOLOGY:

Theoretically the modern trend is away from concern with content alone though facts are still important. Many authorities, however, claim that mastery of content is merely a means for attaining the more intangible aims of science instruction. These objectives are outlined in the Curriculum Guide and include: use of the scientific method in solving everyday problems, suspended judgment, critical mindedness, and the like.

1. 'The Intangibles' and The Facts of Science

   a. Do you consider the mastery of content the prime concern in science teaching? (yes no)

   b. Do you teach for these intangibles listed above deliberately and definitely? (yes no)

   c. If YES to (b), please mark the following outcomes in order of importance (1, 2, 3)

      a) problem-solving ability (scientific method)___

      b) problem sensitivity ____

      c) open-mindedness ____

d) understanding of value of science ____

e) scientific interests ____

f) critical and suspended judgment ____

g) any other? ____

d. If NO to (b) please check your reason:

a) take up too much time for deliberate effort ___

b) too nebulous for effective teaching or evaluation ____

c) mastery of logically-organized content offers most to the student. Intangibles are superfluous ____

d) they will best develop as an adjunct to effective factual teaching; therefore concentrate on understanding of content ____

e) their growth is so slow that one year's development is hardly noticeable anyway ____

f) any other reason? _____

e. If you are definitely concerned with teaching for these intangibles please check (1, 2, 3,) the methods you find most expedient.

a) trying to develop them incidently during routine teaching ____

b) adapting experimental work to stress the 'scientific method' more than is usual in formal work _____

c) giving projects requiring individual research and thought _____

d) organizing my course so that principles and concepts are discovered by methods requiring research, open-mindedness, critical judgment etc._____

e) relating facts to outside world and students' place in it ____

f) Any other? _____

f. If you are deliberately concerned with evaluating growth toward these intangible ends please indicate (1, 2, 3) the devices you find most expedient:

a) personal observation of pupil's day-to-day work and attitude _____

b) use of rating scales _____

c) use of special 'thought' questions _____

d) observing pupil when given responsibility _____

e) by considering the mark on formal tests as indicative _____

f) any device of your own? _____

g. I believe that these intangibles are worth teaching for but as evaluating them is such a subjective business it is better avoided. (yes no)

h. The Course Bulletin mentions the development of meaningful and 'functional' concepts as a desirable

outcome of science teaching. Some people class this as an intangible outcome; but many traditionally-minded teachers will list this as one of their aims too. Please check your attitude toward this objective.

a) I think this aim can be best attained by a logical presentation of the facts of science _____

b) I think this aim can be best attained by reorganizing our subject matter around these concepts _____

c) Teaching for 'functional concepts' is too indefinite; let's see that the pupils are well grounded in the basic facts of science ___

i. What is your opinion of the integrated course? Please check.

a) tends to be superficial ____

b) by destroying the logical framework of specialized science it lessens the value of science instruction _____

c) is well adapted for growth toward the intangible ends _____

d) helps in growth of meaningful concepts by making the facts more meaningful _____

e) any comment of your own? _____

2. Teaching and Testing:

a. Facts are still important. Please indicate the relative importance of the methods you use to present the facts of the course:

a) direct teaching including demonstrations ____

b) pupil reading with note-taking or reports ___

c) committee work and reports _____

d) panel discussions, class discussions _____

e) using experiments and demonstrations to present or clarify ideas _____

f) developing work through written or oral questioning _____

g) pupil presentation of parts of the course ____

h) any method of your own? _____

b. Do you regard constant testing as a vital part of your program? (yes no)

c. How often do you give formal tests? (At regular intervals; at end of convenient amounts of work; both)

d. Do you give 'comprehensive' tests e.g. Christmas or Easter tests (yes no)

e. Please mark in order of importance the purposes for which you give tests:

a) to get a mark for the pupil _____

b) to diagnose difficulty _____

c) to determine mastery of content _____

d) To motivate the pupil _____

e) to indicate growth in the intangibles _____

f) any other reason? _____

f. Many types of questions are used to determine mastery of content. Please check the following (1, 2, 3) in order of their importance to you.

a) short question and answer ____

b) fill-in-the-blanks _____

c) completing or drawing diagrams _____

d) problems _____

e) multiple choice _____

f) essay type _____

g) true or false _____

h) any others? _____

g. Do you make it a policy to give marks for work other than performances on formal tests? (to a great extent, to a limited extent, never)

h. Please check those of the following for which you give marks:

a) reports -- individual or committee _____

b) performance on experimental work _____

c) notes _____

d) work done on projects _____

e) attitude toward work in general _____

f) any others? _____

i. How do you compute the final mark for the year's work? Please check.

a) from a single end-of-the-term test _____

b) from several major tests spread over the term _____

c) from several factors taken together (tests, notemarking, attitudes, appraisal of student's work on projects etc.) _____

j. Do you present a preview of each unit? (yes no)

k. Do you pay special attention to the acquiring of a scientific vocabulary? (yes no)

l. To what extent are pupils urged to look beyond the classroom for scientific information or for lessons in the value of science? (greatly, somewhat, never)

m. Do you use the suggested unit outlines in the curriculum guide? (consistently, frequently, rarely)

n. To what extent do you find the suggested procedures in the Curriculum Guide valuable? (always, often, rarely)

3. Experiments and Demonstrations:

a. To what extent do you demonstrate and experiment? (constantly, often, rarely)

b. To what extent are the pupils able to demonstrate

or experiment by themselves? (frequently, somewhat, rarely, never)

c. Please check (1, 2, 3) in order, of relative importance the purposes for which you use experiments and/or demonstrations.

a) to establish scientific principles _____

b) to illustrate principles already taught _____

c) to give pupils manipulative skill _____

d) to enable pupil to do work on his own _____

e) to illustrate 'formal' method of scientific investigation _____

f) to train pupil in orderly work _____

g) to present a method of investigation to carry over into life _____

h) as one good means of getting a mark _____

i) to train pupil in careful observation _____

4. The Authorized Text:

a. How do you use the text? (exclusively and unchanged, reorganized for my own convenience, as a main point of reference among others)

b. Please check the following. They refer to the authorized text. A -- agree D -- disagree

a) avoids superficiality _____

b) challenging to the student _____

c) questions and problems adequate _____

d) diagrams are pertinent _____

e) previews and summaries are good _____

f) demonstrations are good _____

g) unit organization is helpful _____

h) integration here is effective _____

i) does stress formal experimentation enough for Grade 10 _____

j) well-adapted for instruction in the intangible outcomes _____

k) well-adapted for developing major concepts from the subject matter _____

l) any observation of your own? _____

---

1. Have you any comments on the course in general which you would care to put down?

   a.

   b.

   c.

2. Would you be interested in a summary of the results of this survey? (yes no)

APPENDIX B

APPENDIX B

COVERING LETTER TO QUESTIONNAIRE

11532- 140 Street,
Edmonton, Alberta,
May 30, 1954.

Dear Fellow Teacher:

For the purpose of writing an M. Ed. thesis, I am at present investigating the new Science 10 course with special reference to its background, its objectives and its actual classroom presentation. As the essential factor is, of course, the classroom situation, the success of the entire project depends upon the enclosed questionnaire. For this reason I am making a friendly request for a few moments of your time. In a pinch, even a partial answer will be welcome.

The questionnaire is designed to reveal as fully as possible the following: training of science teachers, teacher's attitude toward the aims of science teaching, school and classroom facilities, methods used in teaching and evaluation.

I might add that all information you may reveal will be held in strictest confidence. There is no need for a signature.

Thanking you in advance for any consideration you are able to give my request, I remain,

Very sincerely yours,

Douglas Jardine,

(Westmount School, Edmonton)

B29773